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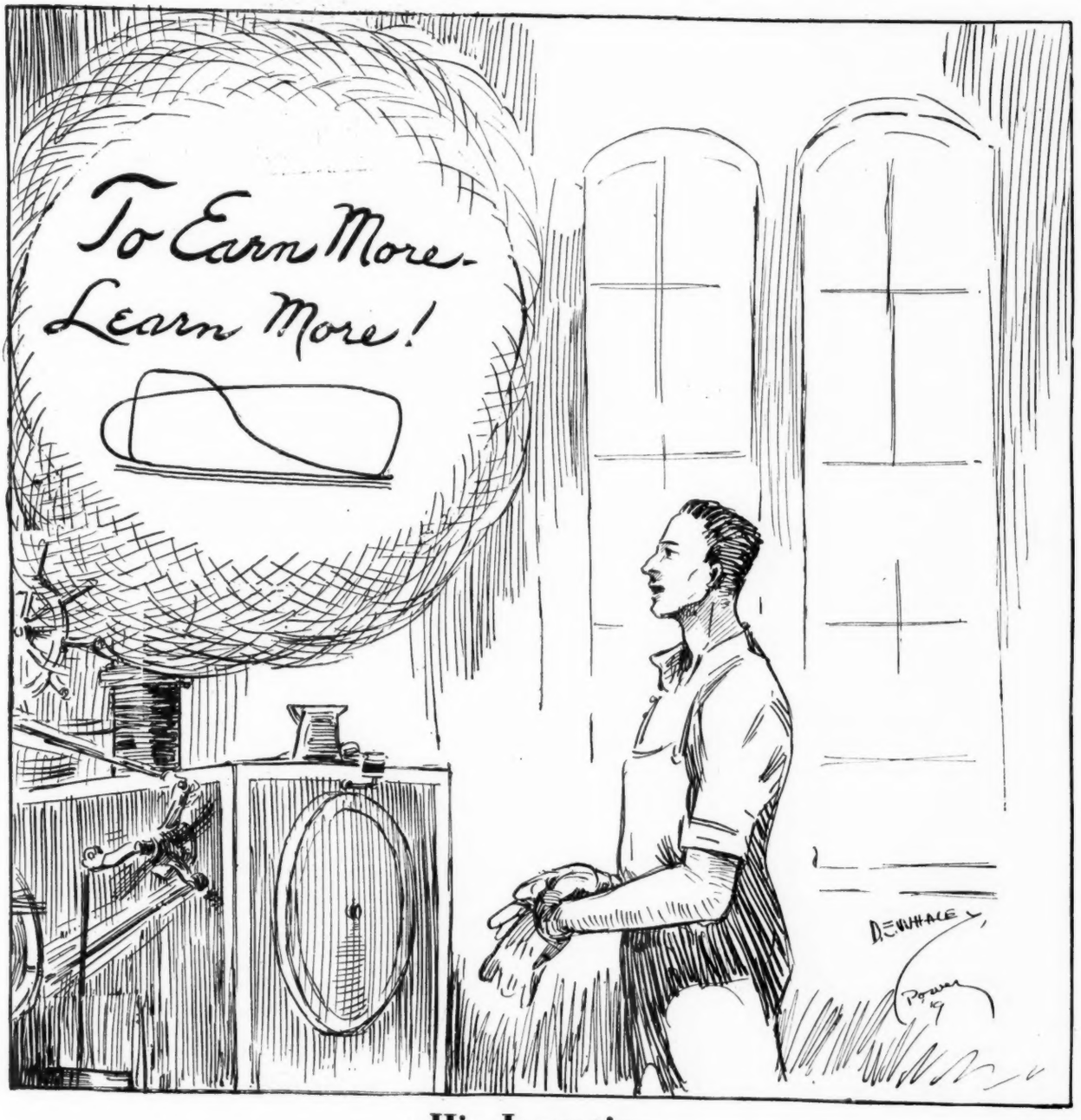
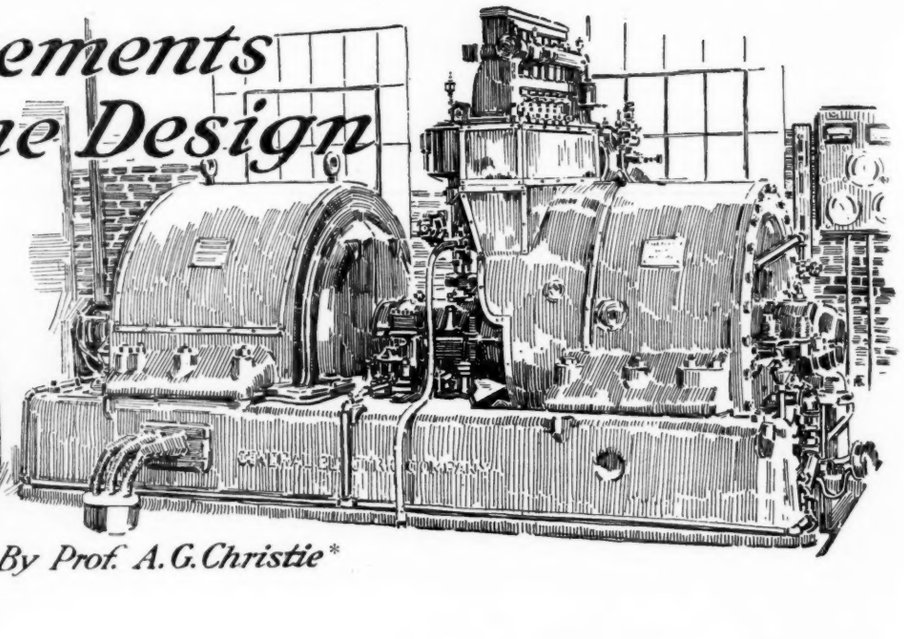


His Incentive

Refinements in Turbine Design



By Prof. A. G. Christie*

The article deals with some of the things which are open to improvement, thus decreasing the steam consumption. Forms of throats and mouths of nozzles, polished surfaces for diaphragms and thickness of blade edges are among the things considered.

REPORTS of tests of large steam turbines that appear from time to time in the technical press show progressive advances in steam-turbine design. Steam consumption in pounds of steam per kilowatt-hour is quite low in some cases, though this is partly due to increased steam pressures and superheat and to high vacuum. The increase of the efficiency ratio referred to the Rankine Cycle has, however, been the best means of judging the improvements and refinements in design, and this ratio has increased practically since turbines were first built. The efficiency ratio on some recent turbines has reached a comparatively high value, and this leads one to consider the line of future turbine development that can still further increase this ratio.

Before entering into a discussion of the possibilities in this direction, it is well to direct attention to some factors in the relation of efficiency ratios and commercial steam-turbine design. A high efficiency ratio in a turbine indicates that its losses are reduced to a small amount through clever design of parts, through the use of small clearances and usually through the use of many stages. This means a large, expensive, carefully built machine which requires care in operation. On the other hand, its high economy makes it very desirable when its load factor and use factor are high and coal is expensive.

Such a high-grade machine is not necessary or desirable for many services, particularly when coal is cheap, load factor and use factor low, and skilled operators not available. Hence, manufacturers furnish smaller, more compact, cheaper machines for such services in which clearances are larger, reliability is increased, and the efficiency ratio is held only at a moderate figure. These machines give good service with little expert attention and serve the purpose for which they were designed.

The war has projected into the problem of steam-turbine design two new factors which are sure to have considerable influence on future machines. These are increased fuel costs and increased labor costs. Apparently, the power-plant operator can do little to decrease these costs under present conditions, so that if he is to reduce his production cost of power, he must look to a higher efficiency in main power units. In this article it is intended only indirectly to indicate the possible economies in the use of fuel through securing higher efficiency ratios in steam turbines and thereby decreasing the fuel consumption. The following paragraphs will therefore briefly suggest some further refinements in steam-turbine design that may secure the desired results.

It is hardly likely that the efficiency ratio can be greatly increased in a given turbine by a modification of any single factor in design. Improvements must be sought in refinements of the design of many of the turbine elements, a few tenths of 1 per cent. here, a few more tenths there, and still a few more tenths in several other places, which in the aggregate may result in marked improvement in the total efficiency ratio of the unit. These small amounts will be secured largely as the result of extended research, test and study of design. The expense of such development work often prevents some companies from undertaking it, but competition will force many to do much of this in the near future.

Probably more experimental work has been done on nozzles than on any other turbine part. Their efficiency is fairly high, ranging from 88 to 94 per cent. There is still an appreciable margin for improvement in this efficiency. As a nozzle alone the circular throat and mouth give the most efficient form. When the delivery of the jet onto turbine blades is considered, the two ends of the jet from an eliptical nozzle mouth do not completely fill the blades they enter and eddies are set up. This is overcome with a rectangular mouth.

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Should the nozzle, therefore, have a square throat and rectangular mouth or a round throat and rectangular mouth, and what should be the relative length, flare of sides and size of mouth for various diameters of throat and ranges of expansion? Further experimental work on nozzles in the light of Martin's recently published theory offers some possibilities for the improvement of nozzle efficiency.

In multiple-stage impulse turbines the orifices in the diaphragms usually consist of sheet-steel partitions bent to form and cast in place. These seldom have a high polish and in any case corrode more or less in service. Friction losses would be decreased were these made of a brass or bronze that could be highly polished and

FIG. 1. BEHAVIOR OF JETS IN BLADES†

would retain the polish. Furthermore, there is reason to believe that a certain amount of eddying takes place in these orifices which might be prevented if the rear of the orifice were flattened out to conform to stream lines in the same manner that blades are thickened at the center. Such built-up orifices have been used by one manufacturer, and improved results are reported.

Friction losses in steam jets crossing blades are very difficult to determine accurately. The condition of the blade surface, whether rough or smooth, is an important factor. The correct width of blade is another factor. A wide blade would appear to reverse a jet with least shock, but the added length of wall increases the surface friction. A narrow blade may cause shock and eddies by too sudden reversal. The blade must be wide enough and thick enough at the center to withstand shock and keep vibration to a minimum. The thickness of the blade at the center and the stream-line effect of the flowing jet are factors deserving much attention. Apparently, much study can still be devoted to blading material and blade shapes.

Several companies building impulse turbines have adopted the practice of increasing the inlet angle of the blades beyond that required by the velocity diagram. In England this is said to have practically no effect on economy at full load and seems to improve performance with low steam pressure or at light loads. A study of the effect of shock on moving blades will indicate how far this inlet angle may be increased to advantage.

The thickness of the inlet and outlet edges of the blades has been varied over wide ranges. Usually, this thickness has been governed by manufacturing and mechanical requirements rather than by a consideration of the effect of shock on the steam jet. The edges must be thick enough not to wear away rapidly from erosion or corrosion. Too thin edges do not make strong blades. Most impulse blades now have a distinct thickness on the inlet side. Here, again, a study of shock on blades might indicate a form of blade edge that would conform more to divide stream lines of the flowing jet and thus lessen shock at this point.

†Illustrations from among those that will appear in Marine Engineers' Handbook.

Several turbine builders, both in this country and in Europe, have made it a practice to give a high polish at all interior portions of their turbines that are exposed to moving steam. This is an excellent plan and could be adopted by all builders.

In impulse turbines the friction losses of the disks are of considerable magnitude, particularly in the high-pressure stages. The whirling losses due to churning in the blades which are not filled with a stream jet are also relatively large in the high-pressure sections of the turbine. European designers are said to be building their diaphragms so as to inclose the disks and blades more tightly than heretofore. One American builder has inclosed the rotating blades that are not opposite nozzles by a U-shaped cover to decrease this whirling loss. Another manufacturer uses a small-diameter disk on the first stage and allows the disk diameter to increase progressively to the last stage. This lessens the disk friction in the early stages when the steam is more dense and also decreases the ratio of empty to steam-filled blades on the disk. There are, therefore, some refinements possible in disk and diaphragm design that may appreciably decrease the whirling losses.

Cast iron is subject to growth when continuously exposed to high temperatures. Hence, the high-pressure cylinder section and diaphragms of turbines using high pressure and superheat must be made of cast steel thoroughly annealed. This is expensive construction,

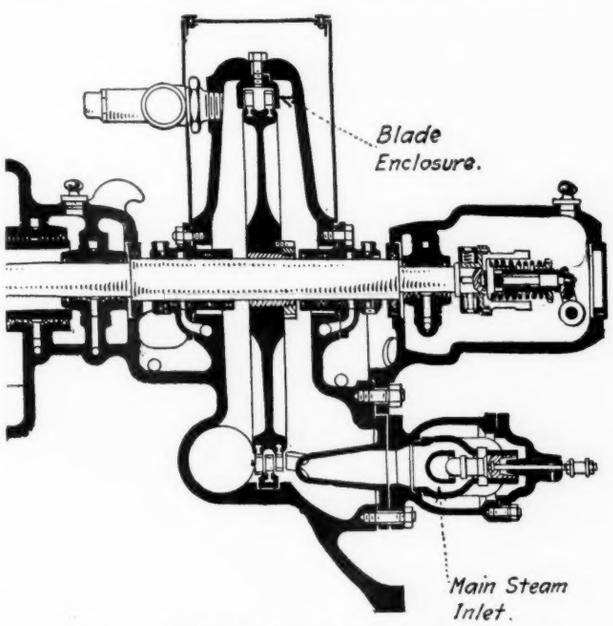


FIG. 2. SHOWING ENCLOSURE FOR BLADES

but must be used to avoid accidents resulting from distortion due to the growth of the cast iron.

A water gland consists of a small centrifugal pump impeller fixed firmly on the turbine shaft and designed to maintain a solid band of water under a pressure of 10 or 15 lb. around the periphery of the impeller. This band of water prevents air leaking into the exhaust ends of the cylinder casing. As a centrifugal pump its efficiency is low, and generally little attention is given to the design of the impellers to get improved efficiency. The power required to drive this pump may be materially reduced by giving it the careful attention that a high-grade centrifugal-pump design involves.

Labyrinth packings are used extensively for casing

glands and diaphragms. Some experimental work abroad showed that there was a great difference in the steam leakage past various forms of labyrinth glands. These forms of glands have only recently received much attention in this country. Improved designs should decrease gland leakage materially.

All the earlier labyrinth glands had the labyrinth teeth cut on the stationary element. If a serious rub occurred it was on a portion of the rotating shaft where quite excessive heating often developed which frequently resulted in a sprung shaft. This design is wrong. A

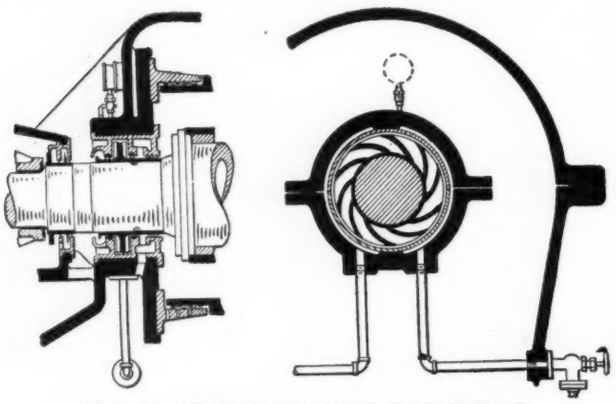


FIG. 3. SECTION SHOWING WATER SEAL

much better plan now being adopted by an American manufacturer is to cut deep, thin labyrinth teeth on the rotating shaft, leaving the diaphragm comparatively smooth. If a rub now occurs, the fine teeth dissipate the heat before it reaches the shaft proper. There is less chance for local overheating to spring the shaft, and there is also more opportunity to introduce improved gland constructions.

The efficiency of the Parsons turbine could be considerably increased if leakage losses over the ends of the blades could be diminished. The clearances over the ends of these blades are fixed by mechanical considerations and probably will not be decreased beyond present practice. It is questionable whether any shroud device with labyrinth packing over the blade tips would decrease leakage sufficiently to offset the increased whirling losses. However, the labyrinth packings on the sides of blades in the Ljungstrom turbines suggest some similar construction for Parsons units which may eventually be worked out to decrease leakage losses.

For highest economy the blade speed in impulse turbines should be about 45 per cent. of the steam speed and in Parsons turbines about 90 per cent. These values are not realized in practice, for to do so either the steam speed must be low and the number of stages large or if the number of stages is to be few the wheel speeds become too high. Many stages mean large expensive turbines, hence designers have aimed toward higher wheel speeds. Large turbines with blade speeds of 860 ft. per sec. are operating. If this figure is to be exceeded, some form of alloy steel must be employed for disks and blades which will safely withstand these heavy strains. Some designers prefer quite moderate speeds, sacrificing economy to safety. There is every probability, however, that blade speeds will be increased as experience in steam-turbine materials accumulates.

Vibration in turbine blading is still one of the engineer's most difficult problems. Little is known of the theoretical nature of this vibration, though it is generally assumed to be of the nature of a harmonic. Does the blade act like a beam held at one end and uniformly loaded? If so, what is the effect of the shroud and of intermediate lacing? Finally, does it have a period of vibration due to the steam velocity? If the theoretical analyses were fully developed, engineers would be able readily to devise means for overcoming vibration.

Parsons-turbine design presents quite another set of problems to that of impulse turbines. Reference has already been made to water glands and to leakage over blade tips. Leakage past the balance piston is a source of loss that may be reduced. The form of dummies in such pistons may be subject to modification so that this loss can be considerably diminished. One form proposed carries several faces on each dummy which cause repeated throttlings as the steam seeks to leak inward over the dummy.

Parsons blade forms are largely the result of cut-and-try methods. The front and rear curves of the blades, the effect of thickness at the entering and leaving edges and the reinforcing of these blades against vibration are matters demanding further study by the engineer. In reference to the effect of thickness on the outlet side, British engineers are inclined to believe that this has no effect on stream flow. American designers believe that it has some effect and generally make allowance for this thickness.

Another theoretical consideration in Parsons' design is the effect of the carry-over velocity from one row on the succeeding row. Does the jet continue into the next row at the absolute leaving velocity of the preceding row, or is this velocity reconverted into heat and thus partly lost as reheat? Apparently, part of both these effects takes place, though to what extent is not definitely established. If the jet can be continued without reheating effect, a possible gain might result.

The wear of blading materials is an important consideration. Many troubles with blade failures have led to an intensive study of blade materials. The first and

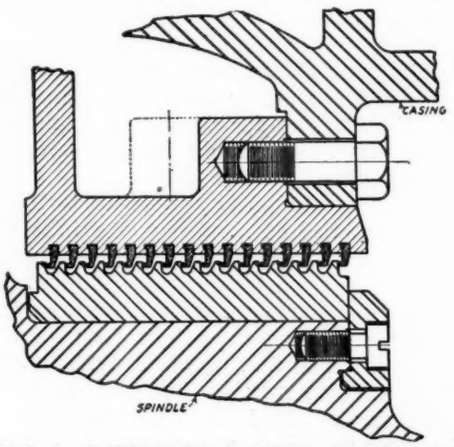


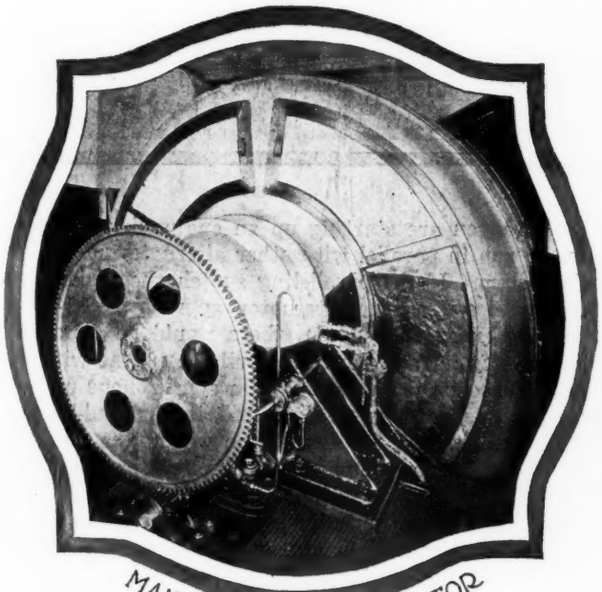
FIG. 4. LABYRINTH PACKING IN SECTION

last blades usually are subject to the most extreme conditions. The first have to withstand high temperature; the last are subject to wet steam and at the same time to high centrifugal forces and sometimes to severe vibrations. Much remains to be done to develop the best material for these two extreme conditions. At present no material seems available to fulfill all the desirable requirements of either.

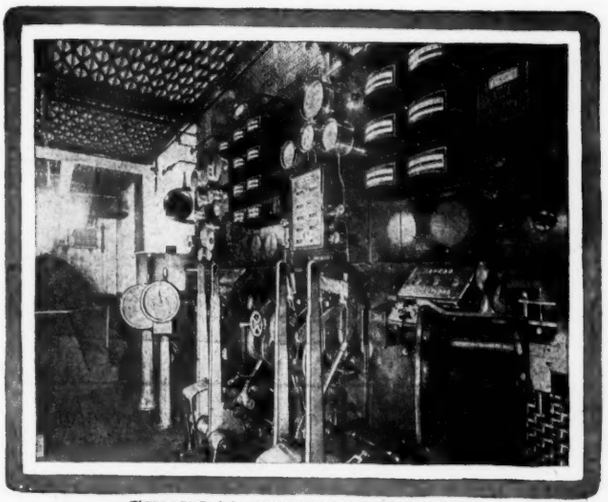
The preceding paragraphs outline briefly some of the problems of steam-turbine design that are occupying the attention of engineers. Owners and operators of turbines are interested in their further development.

ELECTRIC DRIVE OF U.S.S. NEW MEXICO

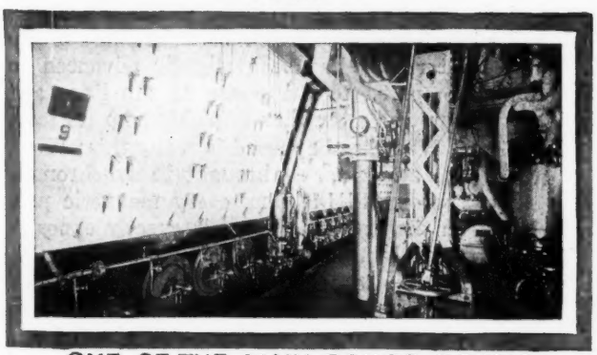
Glimpses Below Decks



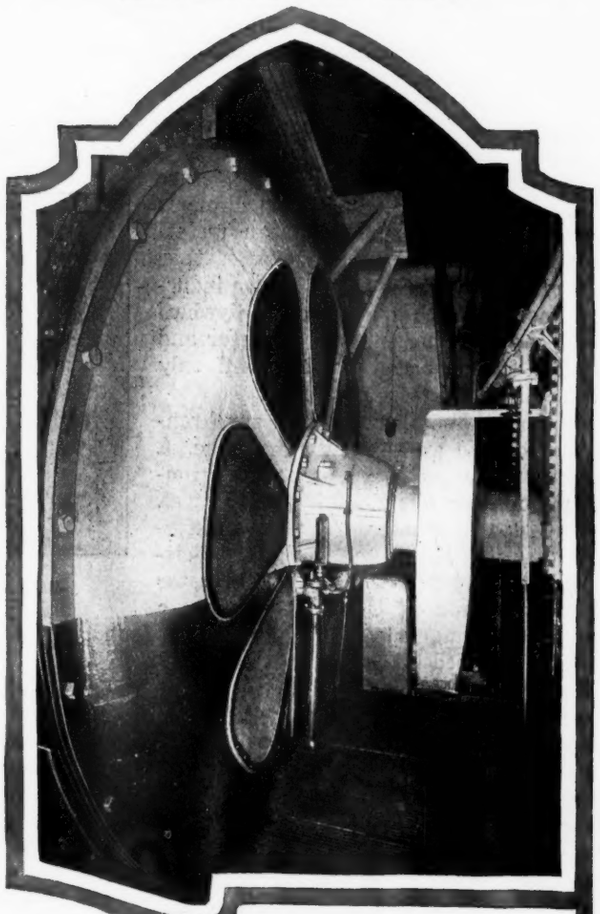
MAIN STARBOARD GENERATOR

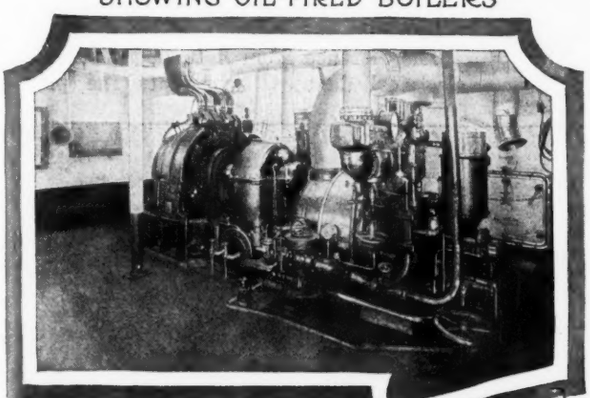


CENTRAL CONTROL BOARD

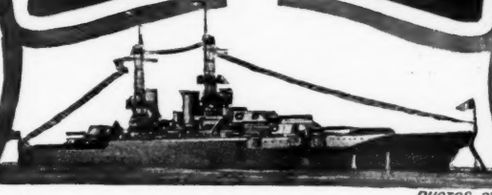


ONE OF THE MAIN BOILER ROOMS SHOWING OIL-FIRED BOILERS



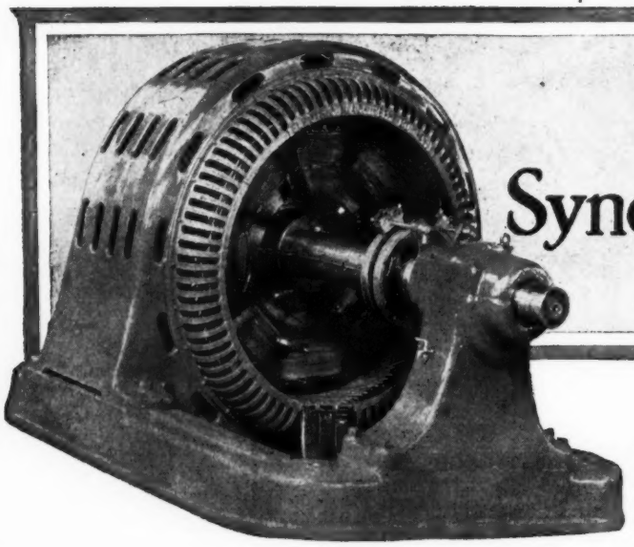


ONE OF SIX TURBO-GENERATOR SETS SUPPLYING AUXILIARY SERVICE



7000-HP. MOTOR DRIVING STARBOARD PROPELLER

PHOTOS BY COURTESY OF GENERAL ELECTRIC CO.

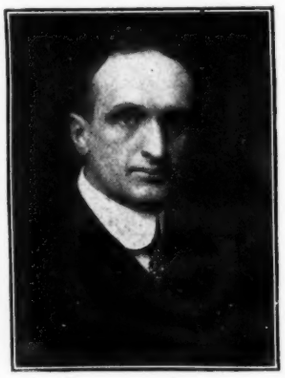


What is the Synchronous Motor?

*By Will Brown**

By comparison with an engine-driven alternator and line sketches showing the relative positions of opposing poles on the rotor and the stator, the author explains simply the actions of the synchronous motor, telling how it is started, how pulled into step, or it falls out of synchronism.

IT IS useless to try to describe a synchronous motor unless the reader thoroughly grasps a few fundamental principles upon which this type of motor operates. If one gets the proper picture of what takes place when a synchronous motor starts and runs, one can understand the real difference between this type of motor and the better-known induction motor. Such questions as flywheel effect, starting current, power factor and overload capacity can be discussed only in the light of this knowledge.



WILL BROWN

As far as appearances go, a synchronous motor and an alternator are alike. A 400-hp. 200-r.p.m. engine-type synchronous motor looks like a 300 kv.-a 200 r.p.m. engine-type alternator. The only difference that will be noticed is the short-circuited squirrel-cage winding on the rotor of the synchronous motor. There are a few other changes in design sometimes found, which will be described later.

Synchronous motors and alternators are made in the same types—direct-coupled, belted, engine-type and vertical. Any turbo-alternator can be operated as a synchronous motor supplying reactive kilovolt-amperes only, or delivering just enough mechanical power to overcome the losses in the machine. Rotor and stator, slip rings, exciter and all other details are practically identical in alternators and synchronous motors. It is assumed that the reader is familiar enough with alternators of various types to render further description unnecessary. Let us consider just what a synchronous motor is doing under various conditions of line voltage and load.

Suppose you are starting up an engine-driven alternator to run in parallel with other alternators on a 60-cycle system. If the paralleling switch should be prematurely closed as the alternator approaches 60-cycle frequency (near full speed), there would be a noticeable tendency to race ahead and pull the engine with it. This corresponds to the pull-in of a synchronous motor. When the alternator is synchronized, it is a well-known fact that raising the field excitation will not cause it to take a load. The ammeter shows a current proportional to the increase in excitation, but the wattmeter indicates no load. The alternator is simply delivering wattless current. Now, if the operator increases the steam supply to the engine, there will be a tendency for the engine to speed up; but this can take place only for a small space of time—a fraction of a second. The frequency of the circuit limits the speed of the alternator. During this infinitesimal period of time the phase of the alternator has been slightly advanced as compared to the phase of the line—and now the alternator is picking up its load.

What has happened is really this: When the alternator is brought to synchronous speed with the line, every magnetic pole on the revolving rotor is exactly opposite a revolving magnetic pole on the stator. A north pole of the rotor and a south pole of the stator are locked together, as in Fig. 2. When the engine is speeded up, the rotor poles move forward as in Fig. 3, and then continue revolving at constant speed with the stator field.

The distance from *A* to *B*, measured in electrical degrees, represents the phase

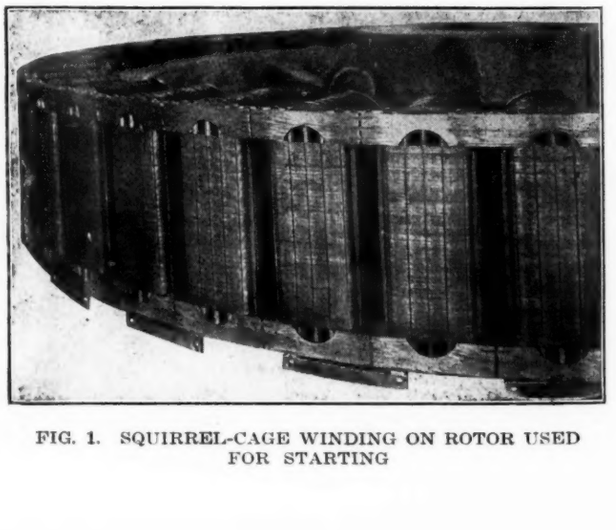


FIG. 1. SQUIRREL-CAGE WINDING ON ROTOR USED FOR STARTING

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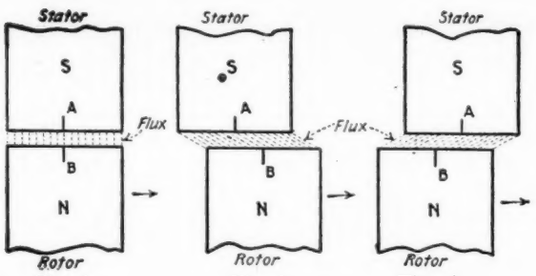


Fig. 2 Fig. 3 Fig. 4

FIGS. 2 TO 4. RELATION BETWEEN ROTOR AND STATOR POLES

displacement. If this distance is increased, the load on the alternator rises; if decreased, the load falls.

Now, suppose the steam is shut off from the driving engine. The alternator will still continue to run and drive the dead engine. It has now become a synchronous motor. Here is what happens: The poles of the rotor drop back from the leading position shown in Fig. 3 because there is no prime mover to push them forward. Almost instantly they are back at the position shown by Fig. 2. But since there is a considerable load now dragging the rotor back (the dead engine), the rotor poles continue falling back to the position shown in Fig. 4.

If the load on the rotor is increased still further, the distance *AB* will increase. It is understood that the excitation has remained constant. This is the condition on a load-driving synchronous motor. The distance *AB*

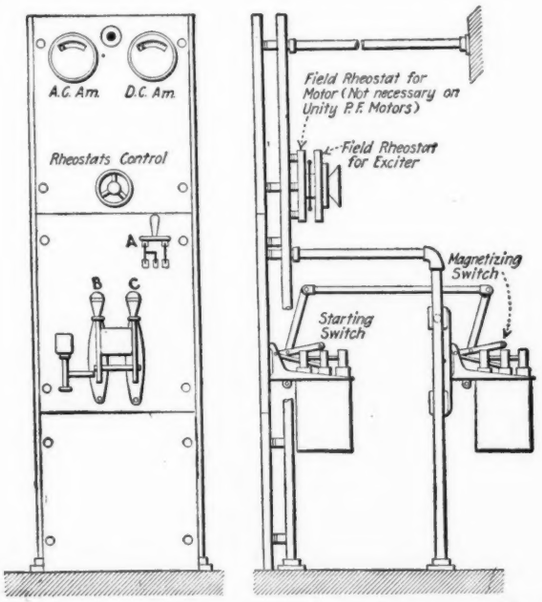


FIG. 5. SYNCHRONOUS-MOTOR STARTING PANEL

is referred to as angular displacement and can never exceed one-half of a pole pitch, or 90 electrical degrees. The amount of load that the motor can carry at any specified field strength (excitation) is limited. When the rotor poles fall back half a pole pitch behind the stator poles, the rotor falls out of step. The force holding together the poles of the stator and the poles of the rotor suddenly snaps like a breaking rubber band, and the rotor stops, while the magnetic poles of the stator continue on at constant speed. This is what happens when a synchronous motor is overloaded and pulls out of step, and is called the motor's pull-out point. Of course, in actual practice the circuit-breakers will generally disconnect the line from the motor before it reaches this point, because of the enormous current that the motor would be pulling from the line. It is possible, then, to draw the following conclusions:

First: The rotor poles of an alternator are being pushed by the prime mover at a certain angular displacement ahead of the stator poles, while the rotor poles of a synchronous motor are being pulled around

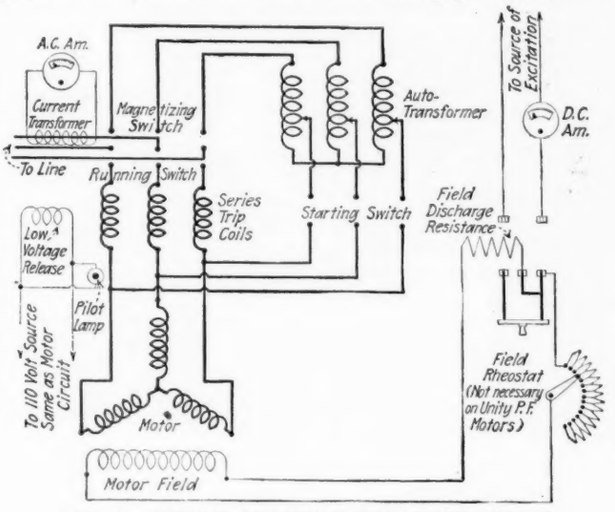


FIG. 6. WIRING DIAGRAM FOR PANEL FIG. 5

at a certain angular displacement behind the stator poles. If that simple fact is kept in mind, it will help greatly in understanding synchronous-motor characteristics.

Second: There is a variation of angular displacement with every variation of load, but there is a limit to the load that a synchronous motor can carry under specified excitation and the angular displacement can never exceed 90 electrical degrees, or one-half a pole pitch.

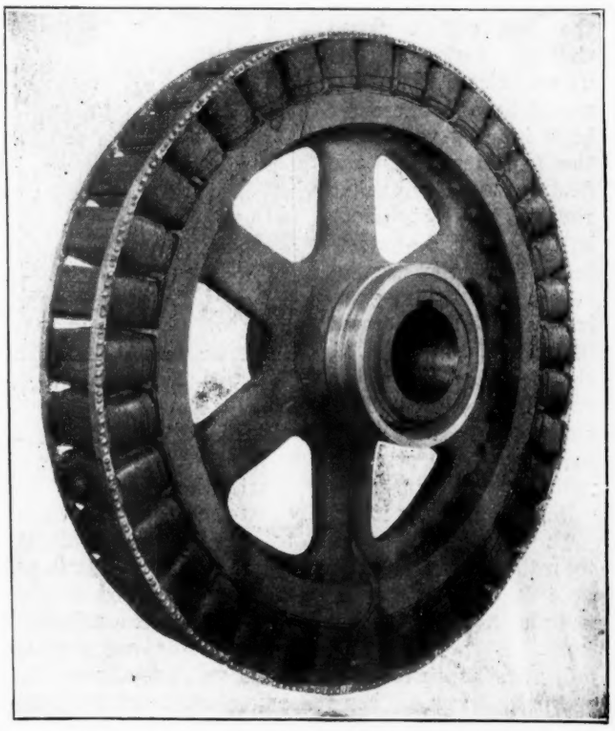


FIG. 7. ROTOR 60-CYCLE SYNCHRONOUS MOTOR

Third: Both the alternator and the synchronous motor can be operated at full field strength without delivering any power except losses in the machine itself. In both cases the current will be reactive or wattless current. This is called running as a condenser.

Fourth: Both the alternator and the synchronous motor can operate only at line frequency, so there is no possibility of variable speed in either case.

Fifth: As in the case of an alternator the synchronizing power increases as the frequency of the alternator approaches the frequency of the line. So it is with a synchronous motor. It is necessary that some prime mover bring the speed of the alternator nearly to syncronous speed before this power is noticeable. Also with the synchronous motor it is necessary that some starting power be used to bring the motor up to a speed approaching synchronism before the pull-in power of the line can be exerted.

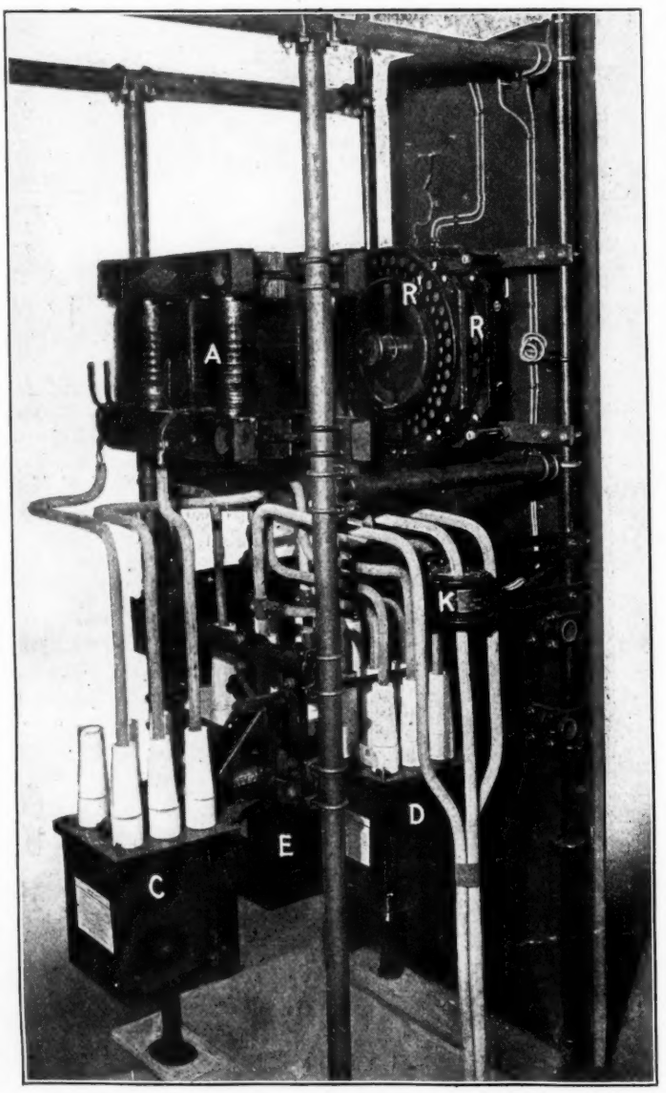


FIG. 8. REAR VIEW OF STARTING PANEL FIG. 5
A—Auto-transformer; C—Starting switch; D—Magnetizing switch; E—Running switch; K—Ammeter current transformer; R—Motor-field rheostat; R—Exciter-field rheostat.

Let us see just what happens when a synchronous motor is started. It is necessary that field switch *A*, Fig. 5, be open and in contact with the field discharge clip so that the field is closed through the field-discharge resistance in series. The motor should always be started with the field circuit closed through resistance; if open-circuited, there would be a dangerously high induced voltage at the field terminals and field switch. The exciter rheostat is set about halfway around at starting. When the starting switch and the magnetizing switch are operated in tandem, as in Fig. 5, the operator throws in switch lever *B*. This closes both the magnetizing and starting switches and immediately starts the motor on part voltage and brings it rapidly up to maximum speed.

The time required for this varies with different cases according to motor design and kind of load. It is possible for a large motor to come up to speed in eight seconds; in some cases it may require half a minute or more. By watching the ammeter, the operator can judge best when to throw on full voltage—the amperes gradually lower. When the ammeter's pointer becomes stationary or practically so, the operator opens switch *B* and closes the line switch *C*, which throws full voltage on the motor. This should bring the motor almost immediately to full speed in step with the line. Just before synchronizing, the ammeter pointer will fluctuate violently and then come to rest as soon as the motor has pulled in. Then the field switch is closed. As a matter of fact, the field switch could be closed before the motor has pulled into step, but the operator must be careful. The motor should generally reach 95 per cent. of full speed before the field switch is closed. If properly done, this will help considerably in pulling in, as it increases the synchronizing power. Most operators, however, prefer not to close the field switch until the motor is at full speed. The motor pulls into step with a fairly heavy rush of current, which falls almost instantly and the motor settles down to steady running. The whole operation should rarely exceed half a minute.

By regulating the exciting current, the operator can bring the motor to unity power factor, or leading if desirable. It is always possible to tell when unity power factor is reached; the line amperes are at a minimum. Any higher resistance or lower resistance in the field circuit causes the line amperes to rise, provided the load remains the same. With a given rheostat setting, in the field circuit, the power factor of a synchronous motor decreases as the load increases, and increases as the load decreases. However this is not a disadvantage as might at first thought be the conclusion, but an advantage, since the excitation may be adjusted to give unity power factor at the maximum load the motor will be required to drive. At loads below this the motor will supply a leading current to the line which will help to compensate for the lagging power factor of the system. In the next article attention will be given to the motor under load.

It is stated that the total mileage under electric operation in the United States is 265,218, against 713,120 for the rest of the world. The former represented 400,000 miles of single-track and there were, in addition, 50,000 miles of street and urban electric railways. There are 675 electric locomotives, as compared with 450 for the rest of the world.

ENERGY STORED *in a* STEAM-BOILER

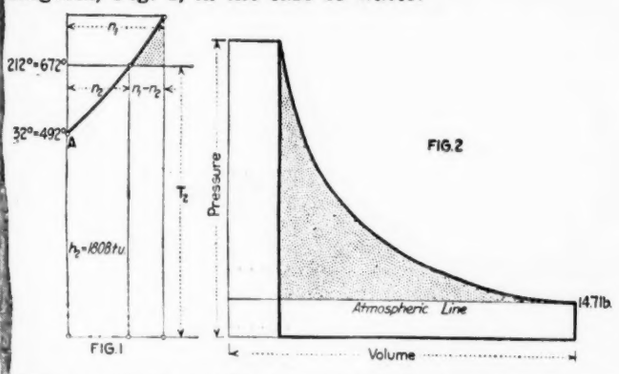
By Fred R. Low

In presenting to legislative committees, industrial commissions, etc., arguments for the governmental supervision of boilers, it is desirable to show how much energy is stored in these receptacles, which lurk under sidewalks, in cellars beneath stores, hotels and other buildings where the public gathers, or in factories where hundreds of human beings toil.

The accompanying table has been computed for this purpose.

Pressure Abs., Lb. per Sq. In.	Energy Stored in Water				Energy Stored in Steam			
	Per Pound		Per Cubic Foot		Per Pound		Per Cubic Foot	
	B.t.u.	Ft.-Lb	B.t.u.	Ft.-Lb.	B.t.u.	Ft.-Lb.	B.t.u.	Ft.-Lb
20	0.18	141.4	10.79	8,392	2.65	2,059	0.13	103
25	0.59	461.7	35.10	27,291	7.97	6,120	0.48	376
30	1.05	819.1	61.98	48,189	13.42	10,436	0.98	760
35	1.56	1,211.0	91.00	70,905	20.65	16,058	1.74	1,350
40	2.23	1,737.2	136.44	106.091	23.85	18,544	2.27	1,767
45	2.75	2,138.7	159.84	124,280	29.14	22,659	3.10	2,413
50	3.27	2,543.7	189 62	147,434	33.88	26,343	3.98	3,095
55	3.90	3,030.0	224.66	174,679	38.32	29,793	4 92	3,828
60	4.59	3,570.8	262 27	203,927	42.84	33,311	5 97	4,643
65	5.16	4,009.4	295.63	229,862	46.81	36,400	7.04	5,471
70	5.76	4,476.0	331.58	257,817	50 69	39,417	8.17	6,354
75	6.33	4,918.2	360.54	280,336	54.25	42,178	9.34	7,259
80	6.83	5,309.2	387.85	301,567	57 79	44,933	10.57	8,218
85	7.43	5,780.5	421.52	327,752	61 05	47,472	11.83	9,282
90	8 01	6,226.1	453.70	352,769	64.20	49,921	13 12	10,204
95	8 65	6,725.1	488.68	379,492	67.21	52,256	14 46	11,240
100	9.16	7,121.6	515.69	400,970	70 06	54,474	15.82	12,300
105	9.77	7,595.6	548.51	426,490	72.90	56,684	17 24	13,406
110	10.25	7,966.9	573.79	446,147	75.56	58,751	18 68	14,523
115	10.86	8,442.7	605.89	471,102	78.06	60,694	20.12	15,641
120	11.34	8,815.2	634.21	493,123	81.58	63,433	21.89	17,019
125	11.85	9,214.5	661.27	514,167	83.02	64,551	23.17	18,016
130	12.32	9,580.4	686.30	533,627	85.32	66,338	24.72	19,218
135	12.95	10,066.2	719.43	559,382	86.50	67,255	25.97	20,190
140	13.35	10,381.1	740.99	576,151	89.70	69,746	27.87	21,670
145	13.81	10,738.2	765.10	594,897	91 70	71,301	29.46	22,909
150	14.26	11,087.6	787.14	612,034	93.64	72,811	31.09	24,173
155	14.74	11,463.5	812.36	631,639	95.78	74,472	32.80	25,507
160	15.23	11,839.5	837.48	651,174	97.62	75,903	34.45	26,786
165	15.74	12,242.3	869.40	672,102	99 41	77,294	36.11	28,081
170	16.23	12,619.4	889.07	691,291	101.27	78,740	37.86	29,433
175	16.72	12,996.6	914.86	711,341	102.92	80,026	39.55	30,754
180	17 17	13,348.2	938.70	729,879	104.75	81,445	41.35	32,154
185	17.69	13,752.1	963.93	749,490	108.52	84,376	43.97	34,189
190	18.21	14,156.0	990.41	770,085	109.11	84,840	45.36	35,075
195	18.76	14,586.5	1,019.78	792,922	109.74	85,329	46.77	36,861
200	19.15	14,887.0	1,039.64	808,365	111.23	86,489	48.61	37,796
205	19.90	15,473.1	1,080.58	840,191	112.73	87,654	50.39	39,181
210	20.02	15,567.1	1,085.14	843,738	114.72	89,203	52.43	40,766
215	20.54	15,972.9	1,113.43	865,733	115.61	89,891	54.11	42,069
220	20.86	16,221.7	1,125.34	874,996	117.06	91,020	55.96	43,507
225	21.35	16,601.2	1,148.68	893,143	118.44	92,095	57.92	45,035
230	21.74	16,902.9	1,167.38	907,684	119.66	93,042	59.71	46,428
235	22.03	17,126.9	1,178.44	916,288	121.00	94,086	61.59	47,868
240	22.48	17,481.1	1,202.82	935,240	122.31	95,100	62.92	49,452
245	22.90	17,809.3	1,223.11	951,018	123.58	96,087	65.50	50,926
250	23.40	18,190.7	1,249.30	971,384	124.82	97,055	67.53	52,507
260	24.21	18,821.2	1,290.19	1,003,171	127.41	99,067	71.48	55,576
270	25.04	19,471.5	1,332.26	1,035,882	129.53	100,713	75.39	58,615
280	25.87	20,111.7	1,373.47	1,067,931	131.72	102,414	79.42	61,756
290	26.58	20,666.5	1,403.39	1,091,190	133.91	104,122	83.56	64,972
300	27.33	21,247.9	1,440 14	1,119,765	135.99	105,736	87.71	68,200
310	28.04	21,803.8	1,475.01	1,146,879	137.29	106,748	91.43	71,094
320	28.82	22,411.9	1,510.38	1,174,383	139.99	108,847	96.17	74,778
330	29.57	22,994.4	1,546.68	1,202,608	141.95	110,371	100.50	78,143
340	30.39	23,629.3	1,586.35	1,233,449	143.82	111,826	104.84	81,521
350	31.07	24,160.8	1,618.92	1,258,778	146.04	113,552	109.53	85,164
360	31.92	24,822.3	1,660.05	1,290,758	147.38	114,590	113.48	88,234
370	32 64	25,380 5	1,694.12	1,317,246	149.13	115,954	117.96	91,719
380	33.36	25,938.7	1,724.71	1,341,029	150.75	117,214	122.41	95,178
390	33.98	26,419.2	1,753.26	1,363,229	152.31	118,425	126.87	98,648
400	34.33	26,691.9	1,767.92	1,374,631	154.51	120,134	132.87	103,315
410	35 31	27,457.8	1,811.59	1,408,586	155.77	121,119	137.08	106,585
420	35.80	27,835.0	1,832.90	1,425,151	157.04	122,106	141.34	109,896
430	36.62	28,473.2	1,871.26	1,454,981	158.31	123,096	145.63	113,248
440	37.94	29,500.3	1,938.76	1,507,467	159.59	124,089	150.02	116,643
450	38.43	29,877 4	1,959.71	1,523,749	161.87	125,861	155.40	120,827
460	39.25	30,515.7	1,993.72	1,550,199	163.15	126,857	161.52	125,589
470	40.07	30,154.0	2,031.42	1,579,508	164.44	127,857	166.08	129,135
480	40.72	31,661.7	2,060.46	1,602,084	165.06	128,341	170.01	132,192
490	41.71	32,430.6	2,106.31	1,637,744	167.34	130,116	175.71	136,622
500	42.53	33,068.9	2,139.26	1,663,363	167.96	130,598	181.40	141,046

It gives, not the entire energy stored in the contents of the boiler, but such portion of that energy as would be available to do damage or create disturbance in case the boiler exploded. This is represented by the shaded area in the pressure-volume diagram, Fig. 2, in the case of steam, and in the temperature-entropy diagram, Fig. 1, in the case of water.



FIGS. 1 AND 2. SHADED AREAS INDICATE HEAT AND ENERGY CONSIDERED AVAILABLE

The formulas by which the table was computed are, for the steam,

$$U = E_1 - h_2 - (N_1 - n_2)\,T_2$$

and for the water

$$U = h_1 - h_2 - (n_1 - n_2)\,T_2$$

where

U = The heat converted into external energy per pound;

E_1 = The internal energy of the steam in the initial condition;

h_1 = The heat of the liquid in the initial condition;

h_4 = The heat of the liquid at 212 deg.;

N_1 = The entropy of the steam in the initial condition;

n_4 = The entropy of the liquid in the initial condition;

n_2 = The entropy of the liquid at 212 deg.

T_2 = The absolute temperature at 212 deg. F.

The table is divided into two portions, one dealing with the water and the other with the steam, and gives the energy that would be released and available to produce disturbance, in addition to the displacement of the atmosphere, for each pound and each cubic foot of contents, and gives these energies both in foot-pounds and B.t.u. The pressures given in the first column are absolute, and the values of the table are the energies developed by a drop from the pressure at the ends of the line to atmospheric pressure, 14.7 lb. abs. or 212 deg.

For example: A horizontal tubular boiler contains 284 cu.ft. of water and 102 cu.ft. of steam. How many foot-pounds of energy would be available to produce destruction if the boiler exploded under 165-lb. pressure absolute:

In the last column of that portion of the table dealing with the water it is shown that when the pressure is reduced from 165 lb. to that of the atmosphere, each cubic foot of the water will release 672,102 ft.-lb. The 284 cu.ft. of water would therefore release

$$284 \times 672{,}102 = 190{,}876{,}968 \ ft.\text{-}lb.$$

In the last column of that portion of the table dealing with the steam, it is shown that expanding from 165 lb. to the pressure of the atmosphere each cubic foot of steam will release 28,081 ft.-lb. of energy available to produce trouble, and the 102 cu.ft. would release

$$28{,}081 \times 102 = 2{,}864{,}262 \ ft.\text{-}lb.$$

The total energy released and available for destruction would be

By the water	190,876,968
By the steam	2,864,262
Total	193,741,230 ft.-lb.

The values used in making the table were taken from the steam tables of Marks and Davis, and in converting B.t.u. to foot-pounds the equivalent 777.54 used in those tables has been employed.

Large Motor-Driven Turbo-Blower

The Tennessee Copper Co. a few months ago, placed in operation at its Copperhill, Tenn., plant, a synchronous motor-driven turbo-blower. The unit consists of four double-inlet wheels contained in two separate casings, each wheel having a separate discharge volute, as shown in Fig. 1. The blower is driven by a three-phase 60-cycle 2300-volt 1700-hp. self-starting synchonous motor, operating at 3600 r.p.m. The extreme compactness of the unit is shown by the dimensions: Length, 32 ft. 9 in.; width, 8 ft. 7 in.; height, 5 ft. 11 in.

The volume of air delivered by this machine is probably the largest ever delivered by a single unit. The blower discharges the air into the main air line, which directs the blast into several copper smelters. When working normally, the machine delivers 125,000 cu.ft. of air per minute at a pressure of 50 ounces.

The Copperhill plant of the Tennessee Copper Co., where this unit is installed, has already in operation several turbo-blowers, also manufactured by the Rateau

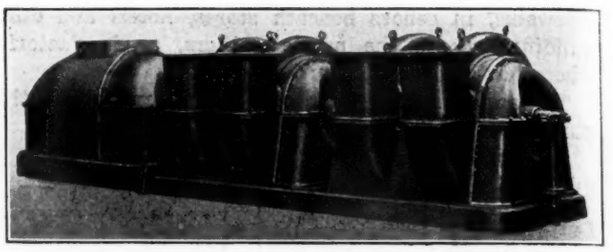


FIG. 1. TURBO-BLOWER AND MOTOR COMPLETE

Battu Smoot Co., New York City. These include a steam-turbine driven unit that has a capacity of 60,000 cu.ft. of air per min. at a pressure of 50 oz. and a motor-driven turbo-blower having a capacity of 12,500 cu.ft. of air per minute at a pressure of 16 lb.

Fig. 2 shows the curves of efficiencies at varying volumes and pressures for the 125,000 cu.ft. per min.

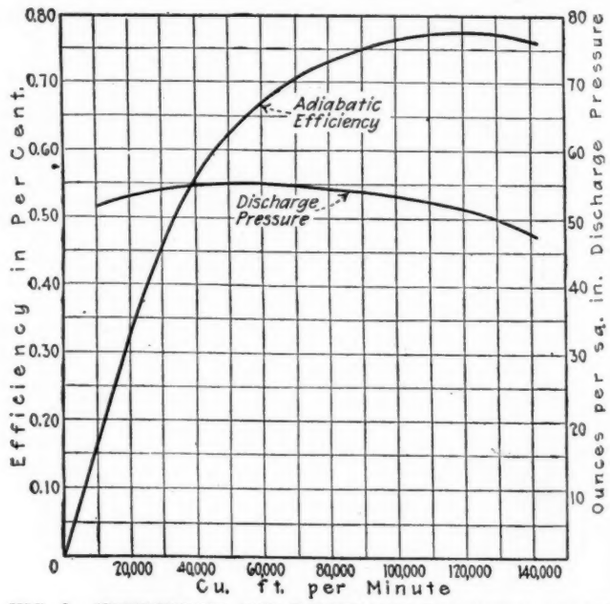
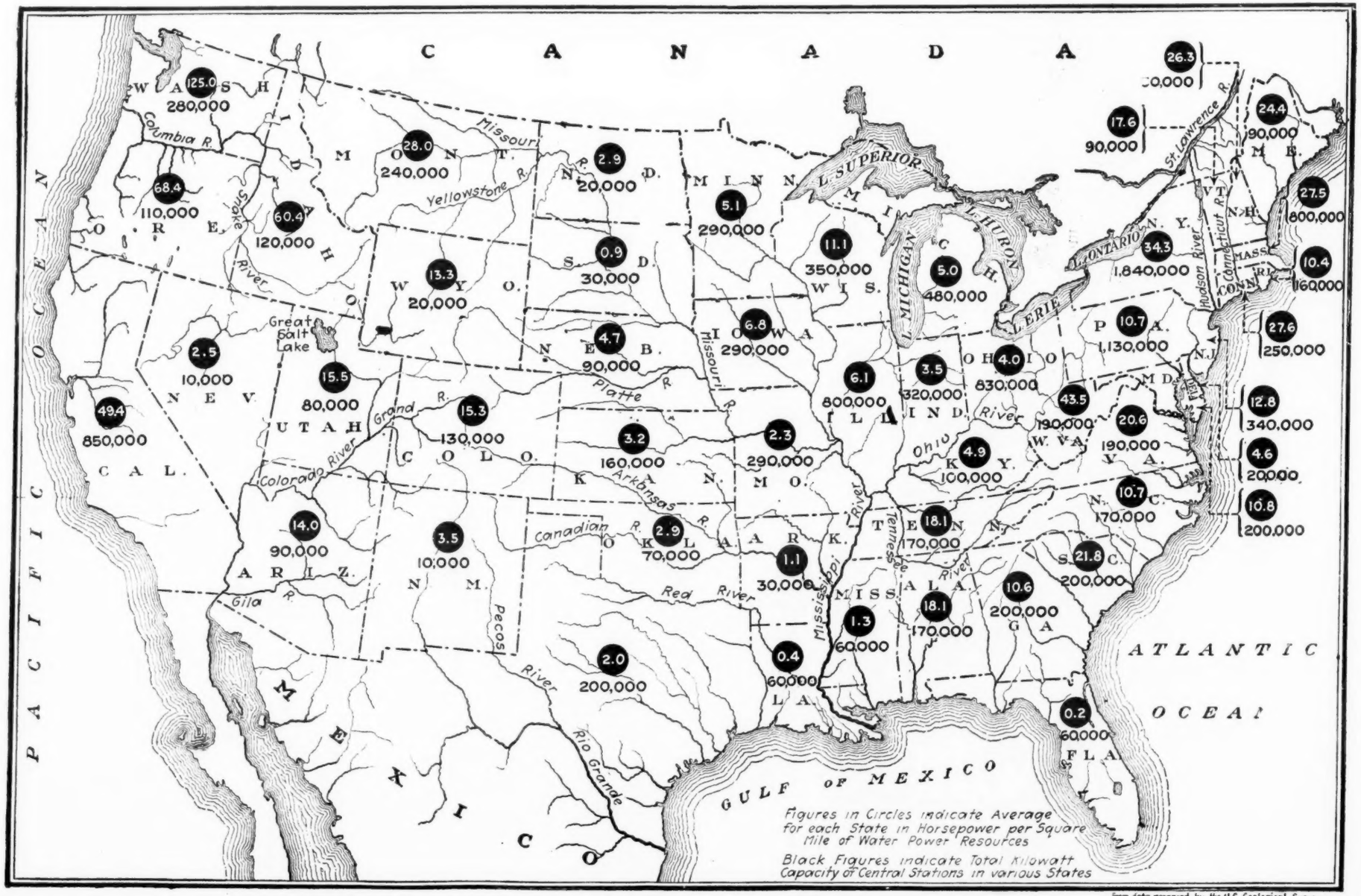


FIG. 2. EFFICIENCY AND DISCHARGE-PRESSURE CURVE

motor-driven turbo-blower to which reference is made in the foregoing.

The steam turbine-driven blower was installed about eight years ago, has been operating continuously for 98 per cent. of the time, and the cost of repairs has been practically nil.

Experiments have demonstrated that concrete is impermeable to oils of low gravity under heads up to 24-ft. Concrete tanks for fuel oil storage have been constructed without any special treatment beyond a rich coating of cement mortar applied immediately after the forms were removed, worked into the surface and then lightly trowelled. In some instances a solution of sodium silicate or water glass has been applied.



From data prepared by the U.S Geological Survey

DISTRIBUTION OF WATER POWER AND CENTRAL STATION POWER IN THE UNITED STATES

Flywheel Bursts at Racine, Wis.

AT 4 p. m. on the afternoon of Aug. 15 a 14-ft., 16-ton flywheel exploded at the Racine Industrial Plant, which supplies power and light to sixteen different tenants. There was one fatality and four men were injured, two seriously and the other two badly bruised. The property damage is estimated at $15,000.

The damaged unit consisted of a simple Corliss engine, 20x42-in., making 90 r.p.m. and operating under a steam pressure at the engine of 135 lb. The speed was controlled by the usual flyball governor belted to the main shaft. The flywheel was of the split type, cast in halves and bolted together at the hub and rim, the rim joints being midway between the spokes. The hub was secured by four 2½-in. bolts and each rim joint had four 2-in. bolts. The rim section was 27 in. wide and about 2½ in. thick with a flange at each edge and reinforcement at the center.

Serving as a pulley the flywheel was used to drive two generators by means of a double belt, the longer belt with 39-ft. centers running over the shorter belt with 29-ft. centers. Both belts were two-ply leather, 24 in. wide and weighing 32 oz. to the square foot. The inner belt drove a 150-kw., a.c. generator through an iron-core paper-rim pulley overhanging from the bearing at the side of the generator. A 200 kw., d.c. machine was driven by the longer belt. This unit was provided with an outboard bearing to carry the driven pulley which was 44 in. diameter and was made up of a wooden rim supported by two sets of iron spokes attached to a single hub.

Both generators delivered 220-volt current. They were never fully loaded, as their combined capacity exceeded that of the engine. At the time of the accident the load on both machines totaled about 125 kilowatts. The engine and flywheel had been in service 14 years.

Throttle Valve Hard to Reach

The engine was located in a corner of the engine room with the flywheel and belts on the inside as shown in Fig. 1, the throttle projecting from the steam pipe, toward the plane of the wheel. From the interior of the engine room the throttle could be reached only by passing around the generators or around the flywheel and engine to the cylinder head. It was an awkward place to reach so that upon the first indication of trouble the assistant engineer rushed for the boiler room to shut off the steam. In doing so he had to pass out a side door and step in line with the flywheel. At that instant the wheel let go, hurling pieces of the rim through the wall and killing him. These pieces are shown in Fig. 3.

In sections varying from 1 to 3 ft. long the rim broke away from the spokes at the points of their smallest cross-sections, leaving the spokes attached to the hub as shown in Fig. 2. Several other pieces coming through the end wall continued their flight through an open space between two buildings housing the Wallace Tractor Co. It was here that the four men were injured. They were working on tractors that had been "parked" in this space. Other pieces of the wheel went through the skylight, the bottom of the flywheel pit was damaged, and on the generator side of the flywheel, a large piece weighing over a ton passed out through the roof, descending into a foundry about 250 ft. distant.

Both generators were so badly damaged that it will probably be cheaper to replace than repair them. On the d.c. machine the pulley was smashed, the field poles were battered and the end windings of the armature badly cut and torn. The rotor was yanked from the a.c. generator into the trench for the belts about 6 ft. nearer the engine. The bearing and pulley were smashed and the frame having broken away from its footings, lay on its side near the foundation, as shown in Fig. 6.

When the chief engineer reached the engine room, he found the engine still running. The governor and its belt were intact and apparently had the engine under normal control. As the steam pipe came up through the floor at the end of the cylinder, it escaped damage. The engineer immediately went to the boiler room and shut off the steam.

It is evident that the governor was not the source of the trouble. It had always given reliable service and continued to function after the accident. Either one of the generator pulleys might have broken, particularly the one attached to the a.c. machine, as it had

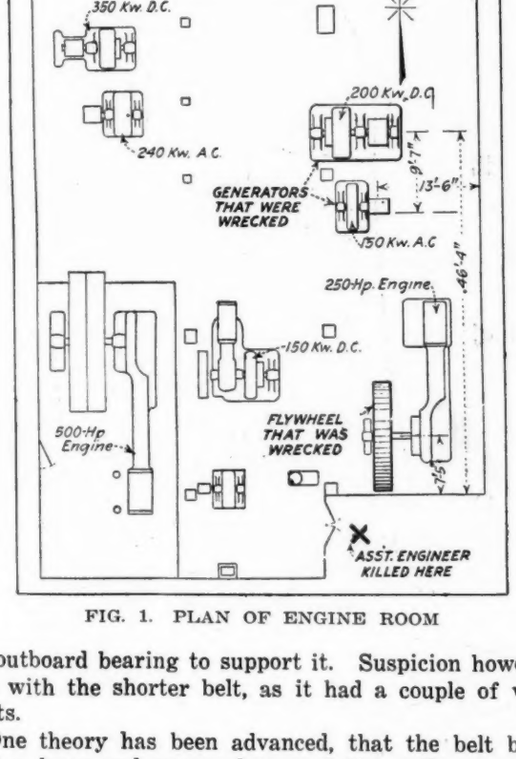


FIG. 1. PLAN OF ENGINE ROOM

no outboard bearing to support it. Suspicion however, lies with the shorter belt, as it had a couple of weak spots.

One theory has been advanced, that the belt broke and a loose end wrapped around the pulley, yanking out the rotor and shaft from the a.c. generator. Then wedging under the longer belt it produced sufficient tension to break it and the pulley as well on the d.c. machine. The damage to the winding was probably caused by flying pieces from the flywheel. Subjected to a shock of this character and perhaps to increased speed after the load had been released suddenly the flywheel let go. The nature of the breakage would indicate centrifugal force as the immediate cause. The spokes all broke near the rim, the fractures indicating metal

uniformly good. Pieces flew equally in all directions and with such force that an increase in speed was probable.

Another theory advanced was that the loose end of the belt might have knocked down something overhead such as the oil piping, which could have rested on the governor arm and have been automatically cleared during the wreck. It is positive that the oil piping and plenty of other things overhead were down after the accident, but it is likely that they were brought down by the flying pieces of the flywheel rim. The first theory seems more plausible. It is significant, however, that the time element between the breaking of the belt and the bursting of the rim must have been very short. Was it long enough for the engineer, after first noting trouble, to have reached the engine room door? This is a matter that should be given weight in attempting to analyze the cause of the accident.

Crab Short-Circuits Generator

A city of about 18,000 inhabitants located in San Domingo, West Indies, is lighted by a 150-hp. oil engine direct-connected to a 100-kw. generator.

The engineer of the plant is a tall, rawboned negro who was born in one of the British West Indian Islands.

Recently, the generator caught fire and the negro, instead of shutting down and subduing the flames, mounted a horse and rode a mile or more to ask the manager what should be done. When the manager arrived at the plant the flames had destroyed half of the generator coils.

Investigation revealed that a crab from a neighboring swamp had taken refuge in the generator frame and as soon as the movement of the machine had disturbed his sleep he had clamped his two claws into the insulation of two coils producing a short-circuit.

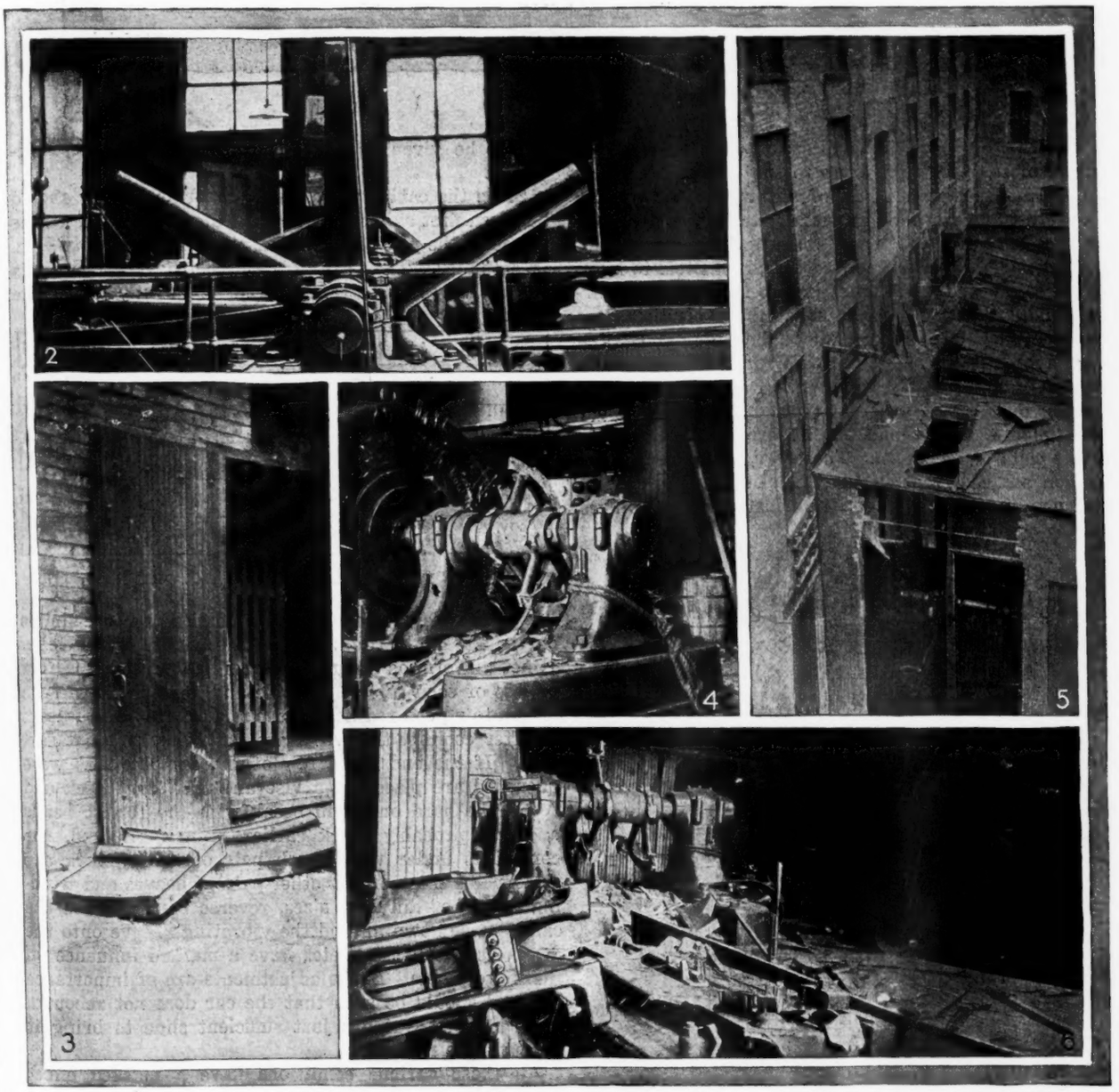


FIG. 2. SPOKES OF FLYWHEEL REMAINING AFTER RIM BURST. FIG. 3. ENTRANCE TO ENGINE ROOM AND PIECES OF RIM THAT KILLED ASSISTANT ENGINEER. FIG. 4. D. C. GENERATOR AFTER THE ACCIDENT. FIG. 5. HOLE THROUGH WALL AND ROOF. FIG. 6. A. C. GENERATOR LYING ON ITS SIDE AND SHAFT OF D. C. GENERATOR

INSPECTION AND INSTALLATION OF ELEVATOR CABLES

By D. Alfred Manson.

INSPECTION and installation of elevator cables is one of the jobs that is up to the maintenance man of almost every building of any consequence today, therefore the method of inspecting, testing and installing these cables should be of interest.

After making a few minor repairs, I was told to make an inspection of the elevators in two large manufacturing buildings and to report in detail the conditions as found. Since that report was submitted, about ten years ago, I have been responsible for the maintenance and safety of these elvators. While I have been responsible for most all the different types of machinery about power plants, I have had but little experience outside of this plant on elevators. Therefore, my system of inspection and maintenance has been built up as an isolated one and is offered both for instruction to others

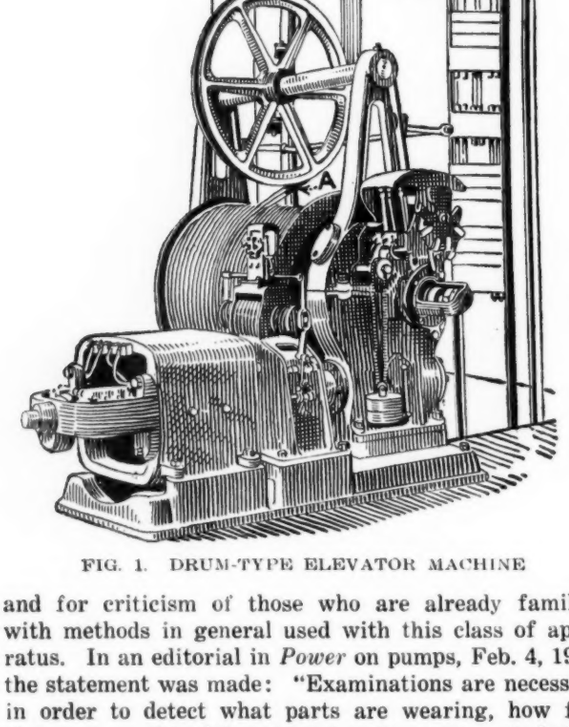


FIG. 1. DRUM-TYPE ELEVATOR MACHINE

and for criticism of those who are already familiar with methods in general used with this class of apparatus. In an editorial in *Power* on pumps, Feb. 4, 1919, the statement was made: "Examinations are necessary in order to detect what parts are wearing, how fast they wear, and to determine when to renew parts before they give out entirely and perhaps cause a shutdown." This statement is applicable to all mechanisms, but it should be given special emphasis with regard to elevators.

Since the cables are of such importance, they should be given first as well as frequent attention. The cables in use in the plant in question range from $\frac{5}{8}$ in. to $\frac{7}{8}$ in. in diameter. They are of soft iron, having 6 strands and 19 wires per strand. I am frequently asked the

CAR Nº 4 SOUTH BUILDING

	DATE INSPECTED	CONDITIONS AS FOUND	BY WHOM INSPECTED	LAST RENEWAL	SIZE & LENGTH
DRUM TO CAR	Jan. 7 1919	Rd. Good Ll. Fair	Anderson Frey	Feb. 10 1911	3/4" 298 ft.
DRUM TO C - WT.	Jan. 7 1919	Poor	"	July 15 1917	3/4" 292 ft.
CAR TO C - WT.	Jan. 8 1919	Bad	"	Dec. 1 1916	5/8" 143 ft
GOV. SAFETY	Jan. 8 1919	Fair	"	Aug. 7 1910	1/2" 286 ft.

FIG. 2. CABLE-RECORD FORM

life of our elevator cable. The question is not a simple one as one might think. First, the quality of the ropes is not uniform as a simple test will show. Take a foot or less of each sample of cable and heat about half its length to a good red heat and plunge it into cold water; if after cooling, the wires are stiff, they are not soft iron. If the ends of a few of the samples that were quenched are placed in a vise and then bent back and forth, the hard ones will break with the fewest bends and will probably crack earlier in use. Second, the conditions under which each pair of cables work are seldom like those of any other pair. Sheaves and winding drums of different sizes, reverse bends, where the cables come down around the vibrating sheave onto the drum, as at *A* Fig. 1, etc., have a marked influence on the life of cable. Brake adjustments are of importance too, and should be such that the car does not rebound, when stopped, but has just sufficient slide to bring it gradually to rest.

All these various conditions have a marked effect upon cable life. To illustrate, take the case in the plant in question where some $\frac{5}{8}$-in. cables are used from car to counterweight on one of the freight elevators. These cables have been in use ever since the elevators were installed, fifteen years ago, and are in good condition yet. On the other hand, a pair of $\frac{3}{4}$-in. cables installed on a passenger elevator from the winding drum to the main counterweight have had to be replaced in less than eleven months. It should be explained, however, that the freight was in use only eight hours a day, while the passenger elevators were in continuous use the whole

twenty-four hours and for seven days in the week. Therefore, the length of time cannot be taken as a measure by which to determine the cable life; their safety must be determined after careful inspection made at the end of regular periods. I have adopted a three-month schedule and have arranged to record the conditions on a form, as shown in Fig. 2.

In order that the condition, such as good, fair, poor and bad, may have a fixed standard, the men are instructed to count the number of broken wires that are seen within a length of an inch and a half on any one strand. Cables showing none or one break per strand are rated good. Those having one break per strand with once in a while two wires per strand broken are rated fair. Cables having a large number of places where two wires are broken per strand and in some cases three wires broken per strand are rated poor. Those having a large numbers of places where three wires are broken per strand and some places where four to six wires are broken per strand are rated as bad. Whenever we can do so, we use a cable of each kind where two ropes are used side by side; that is, a right-lay rope and a left-lay rope, respectively. The abbreviations therefore in the table are intended to show that the right-lay rope *RL* is in good condition and that the left-lay rope *LL* is in only fair condition. The upper rope in Fig. 3 is a right-lay and the bottom a left-lay rope.

Cables reported bad are replaced with new immediately or later according to the several conditions which must necessarily apply to each individual cable, such as dangerously bad, bad but will probably last until other cables have been inspected, or will not need changing until such time as some important work will not be delayed by stopping the service, etc.

I am not familiar with the experience of others, but

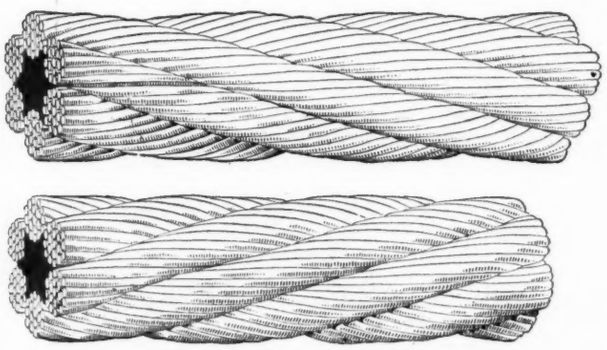


FIG. 3. RIGHT-LAY AND LEFT-LAY CABLE
Top—Right-lay rope. Bottom—Left-lay rope.

we have broken only four ropes out of 96 in use in the last ten years. Two others have stranded; that is, a strand or two have broken, but the rope did not part before the defective rope was detected and removed. On the other hand, we are getting about the limit of usefulness out of the cables as the following incident will show:

A contractor desired to guy one of his derricks and asked if we had any old cables? Some was pointed out to him, but he was cautioned that it was condemned and that if used he must assume the risk. He assumed the risk, guyed the derrick, broke the cable and fatally injured one of his men.

We are getting considerably longer life from our cables now than when the system of inspection was first installed. I attribute this mostly to the care in keeping the cables under equal tension or transferring the greater stress to the better rope of the pair. The ropes connecting between the drum and car and from drum to main counterweight may be easily adjusted by loosening the clamp inside of the drum on the tight or the poor cable, as the case may be, and letting out about one-

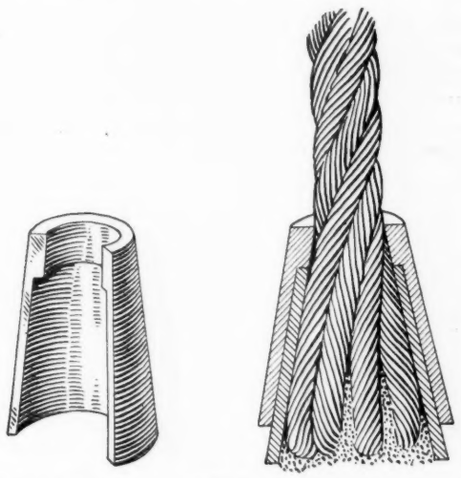


FIG. 4. SPECIAL THIMBLE FOR ADJUSTING CABLE TENSION

half inch at a time until the desired tension is obtained in each.

From the car to the upper or car counterweight, which is usually carried on a pair of cables smaller than the car or the main counterweight cables, there is no provision made for equalizing or adjusting the tension. It is seldom that a new pair of cables are cut exact enough to an equal length to have equal tension when the stress is put upon them. To overcome this defect, a special thimble, Fig. 4, was designed and put in use, which is slipped over the regular bell or thimble in the manner shown in the figure. This device will take up about $\frac{5}{8}$ in. and two may be used if found necessary.

Another simple instrument made and used by the men is shown in the Fig. 5. It was noticed that one of the men was depending upon his finger nails to detect cracks or broken wires, so taking the hint from him a scraper was made, as shown in the figure. The device was first tried out on greasy and dirty cable, also on smooth worn cable and found to be a perfect sleuth for picking up a broken wire. In use the sharp edge is drawn slowly over the cable with a light pressure placed on it with the hand. The sharp edge either enters the crack and stops the hand or gives a slight jump which attracts immediate attention. By the aid of these scrapers we are now able to inspect the cables in far less time and without the headache due to eyestrain.

Having decided which cables are to be removed, it becomes necessary to look into the stock on hand and order when short of any size. Most of the cables are approximately 300 ft. in length, therefore in ordering we obtain that amount or some multiple of 600 ft. on a reel to prevent waste and avoid carrying a large supply in stock.

A convenience at the time of removal is to have proper supports for the reel so that the cables may be unwound direct from reel into their place on the sheaves. A pair of strong horses similar to a carpen-

ters sawhorse but with the legs on one end made shorter than those on the other end, as shown in Fig. 6, are used. Notches are shown on the top of the horse, which allow for swinging any size reel, and no time is wasted hunting blocking or old boxes. When about to remove the old ropes, it will be necessary to locate their ends on the drum in such a position that they can be worked upon. Therefore, placing the drum and at the same time having the proper amount of slack rope to work with will require a careful selection of the blocking to put under the counterweight or the car, depending upon which pair of ropes are to be renewed.

Ropes are always renewed in pairs, because a new one is larger than a used one, and if it were attempted to work a combination of new and old side by side, the larger rope would wind the faster and take all the stress, while the old one, or smaller rope, would develop more and more slack as the pair were wound around the drum. I have found it good practice to use cables of the same manufacture in a pair for this same reason. Otherwise the tension will not be the same throughout the whole car travel.

Having cut loose the old cables from the drum at the point where they pass through it, the turns on the drum are unwound and taken in a straight line to some convenient point where the position of their ends can be marked on the floor. Then the new cables, when they

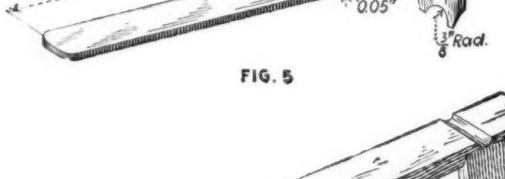


FIG. 5

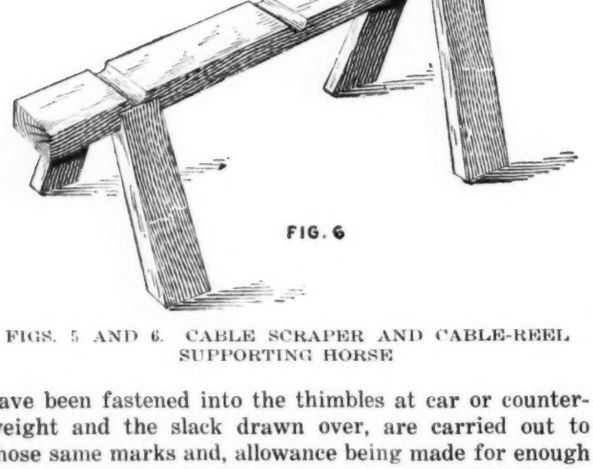


FIG. 6

FIGS. 5 AND 6. CABLE SCRAPER AND CABLE-REEL SUPPORTING HORSE

have been fastened into the thimbles at car or counterweight and the slack drawn over, are carried out to those same marks and, allowance being made for enough to fasten inside the drum, are cut off the length corresponding. In most cases there will be from two to two and one-half turns on the drums which is not unwound in use.

After marking the position of the ends of the old ropes, as described, all the strands except one should be cut away so that the remaining strand protrudes about three inches. This is best accomplished by first wrapping friction tape around the end where the strands are to be cut off, as indicated in Fig. 7. The remaining strand is then doubled back so as to form an eye or loop. The corresponding end of the new cable is treated in the same way, and the two are hooked together and thoroughly taped over. The old rope can now be used to pull the new one into place and will follow without catching upon any obstruction. Some surplus rope should be pulled over so as to give room to work while fastening the bells at the car or counterweight crosshead. When making up these ends, the bell is first slipped over the cable, small end first, and temporarily fastened back a couple of feet so as to be out of the

FIG. 7

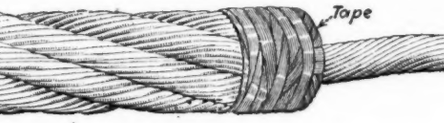


FIG. 8

FIGS. 7 AND 8. ENDS OF CABLES PREPARED FOR INSTALLATION

Fig. 7—Method of attaching two cables together. Fig. 8—End bell in place on cable.

way while making up the end ready to be incased by the bell. A fine iron wire or tape is wound about 3½ in. back from the end of the cable; the strands are opened out and the hemp core is cut off. The strands are then bent back on themselves in such a manner that the ends are all in the middle of the rope, as indicated in Fig. 8. After the bell is driven down over the upset end as far as it will go, some waste or other material is placed around cable at the small end of bell to form a dam, and molten lead is poured into the open mouth of the bell until it is full. The slack is now pulled back over the sheaves, the bells are brought into their proper bearings and the ropes are cut to length, as previously described. After cutting, the ends are passed through holes in the drum, the clamps are put on and the cables are given the load to see if they have equal tension; if not, they are adjusted with the clamps. A good finishing touch is a coat of raw linseed oil over the ropes.

Power Extension in the Monongahela Valley

Precautions to assure a sufficiency of electric power for the future, the culmination of which will mean an expenditure of a million dollars, are being taken by the Monongahela Valley Traction Company. The plan, as announced by President George M. Alexander, includes the doubling of the capacity of the power plant at Rivesville; the construction of new high tension lines to practically every point in the upper Monongahela Valley and the strengthening of the lines already established. Among the improvements to be started immediately are the installation of another large generator at Rivesville; the construction of a new line into Barbour county as far as Meriden and the construction of a 66,000-volt line from Clarksburg to Grafton and then from Grafton to Rivesville.

New improvement which will be put into effect this fall will be the extension of the 66,000-volt line which is now in operation between Rivesville and Hutchinson, on to Clarksburg and then east to Grafton. Following the completion of the line to Grafton, it will be extended down the Valley River to Fairmont.

Straightening Shaft of 45,000-Kw. Turbine

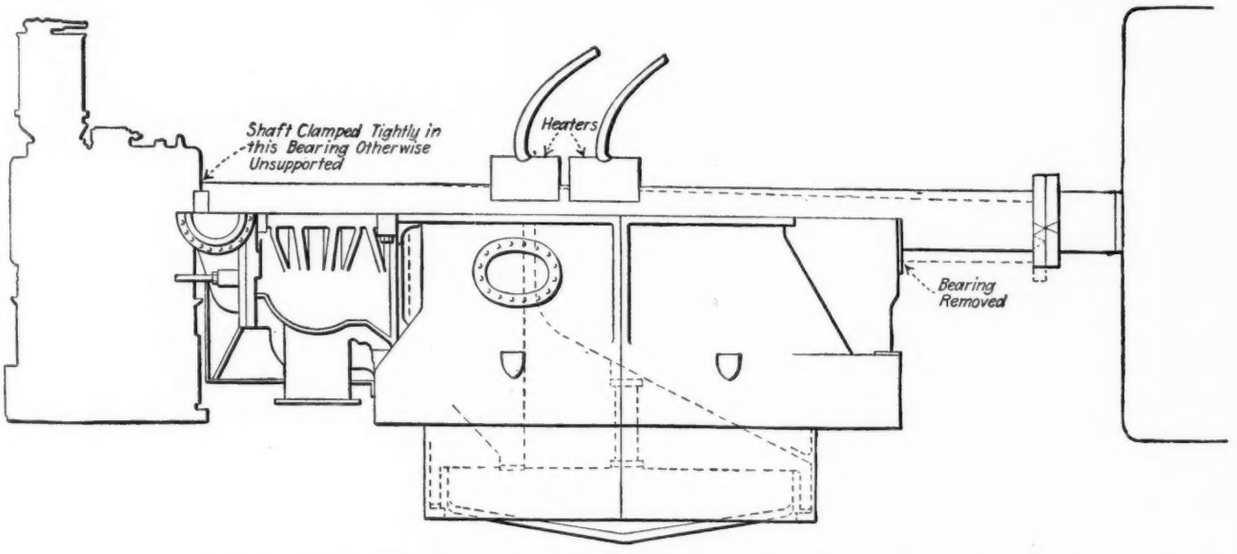
By E. E. CLOCK

IT WOULD seem that steel as used in the fabrication of modern machinery is not yet out of its swaddling clothes, judging by some recent performances in heat-treated steels and the gum-shoeing that prevails in the matter of its development. It would appear that the buyers of such machinery are entitled to more information on this subject. The erratic action of these steels in disks and shafts of steam turbines have rather upset some of the accepted formulas, especially in the performance of the steel under wide ranges of temperature found in turbine practice.

A short time ago a 45,000-kw. turbine became suddenly unbalanced by the loss of several blades on the last-stage disk and badly sprung the shaft. This shaft was straightened by a method that has never been made public, and being a distinct advance in the art, which in this case probably meant the saving of $60,000, a great opportunity to uphold the traditional generosity of the engineering profession was lost by not making it public.

The sprung shaft was stripped of its disks as shown and clamped tightly in the long bearing at the high-pressure end, with the bearing removed at the low-pressure end, leaving this end of the shaft entirely unsupported, the coupling to the generator being removed. To the end of the shaft was secured a scale marked in thousandths of an inch and registering the exact center of the shaft. Alongside of this scale was a target scale, also marked in thousandths and registering where the center of the shaft ought to be, showing and proving by rotating the shaft that it was out several hundred-thousandths. The shaft was placed with its stretched side up, which meant that its center mark on the scale on the shaft was below the center on the target scale. In this position we must take this view of the case: Here was a shaft sprung out of a true line and held so because the metal on the top of the shaft in its present position had become elongated or stretched and was holding the major part of the metal out of line against its natural tendency to come back into line; and if the stretched metal could have been removed, this shaft would almost straighten itself. Now, as this metal could not be removed, the next best thing would be to remove the stretch sufficiently to allow the fibers of the metal in the rest of the shaft to straighten out and just enough more to pull into line when cold against any tendency to remain permanently out of line.

This was accomplished in the following manner: Two airblast kerosene-oil burners, capable of quickly generating great heat, were placed on the top or stretched side of the shaft, the stretched portion of the metal being so quickly heated and expanded as to produce compression of the metal; in other words, the metal was upset. The burners were removed, and as the metal cooled, which it did in a few hours, the two scales began to come into line, and when the shaft had entirely cooled, the center marks on the two scales lacked but six thousandths of being line and line. Another slight heating in the same place resulted in bringing it four thousandths too far. This was corrected by the application of heat to the opposite side of the shaft, which resulted in the exact truing of this costly piece of machinery.



SHOWING HOW THE SHAFT WAS SECURED AND HEATED TO STRAIGHTEN IT

I was present when this machine was first brought up to speed after being reassembled; its performance was perfect and it has been in service since December, 1918.

In another case a shaft of a 2000-kw. turbine was sprung and was streightened by the old method of using force externally.

This shaft was treated by the application of heat evenly while it was kept turning in its bearing until it was again cool, force being applied the same as straightening a piece in the lathe. This method also was a success so far as the operation of the machine was concerned. Unfortunately, however, previous to the attempt to straighten the shaft an order was placed for a new one at $10,000. After the job of straightening

proved all right an attempt was made to cancel the order for the new shaft and an offer was made to pay for the forward work that has been done on it. However, the builders of the machine, who had the order for the new shaft, protested that the repaired shaft was not safe to operate and so prevailed on the officials of the company owning the machine that they ordered the machine down until the new shaft should arrive.

Contrasting the two jobs, it would appear that if the first one was safe the second would surely be much more so. The first-mentioned machine is being carried on an insurance policy for $300,000.

Another recent turbine-shaft failure was that of a 75-kw. machine whose rotor, without exploding, overspeeded after releasing itself from its load by the breaking of the shaft, wrecking the stationary part of the machine, killing two men and finally coming to rest in a distant part of the room after performing some rather fantastic stunts about the engine room.

These three machines were each of a different make and widely different in capacity and were located in Detroit, Brooklyn and Staten Island in the order mentioned.

It is hoped that at coming meetings of the American Society of Mechanical engineers something will be brought out regarding this new art of straightening heavy shafts by the heat-treatment method.

The Limits of Thermal Efficiency in Internal-Combustion Engines

It was generally assumed by engineers as early as 1882 that the steam engine had reached its highest development so far as thermal efficiency was concerned, according to Sir Dugald Clark in a recent paper before the North East Coast Institute of Engineers and Shipbuilders.

In that year the highest thermal efficiency given by a steam engine was 12.7 per cent. of the total heat of the steam used. Assuming a boiler efficiency of 80 per cent. and a 90 per cent. mechanical efficiency, a 9.2 per cent. brake thermal efficiency was secured. But this is far below the record set by modern units.

The steam engine, by the use of triple expansion in cylinder engines, and the steam turbine, by the use of numerous expansions and intensified vacuum, utilized the available temperature range to such an extent that about the year 1914 the large steam turbine gave the indicated equivalent of 23 per cent. thermal efficiency of steam heat and 19.5 of brake-horsepower efficiency. This makes about 16.6 per cent. brake thermal efficiency calculated on the fuel beds of the boiler furnace.

Meanwhile the internal-combustion engine efficiencies have been raised to 35 and 37 per cent. indicated, and about 30 and 33 per cent. brake efficiency.

Considering both steam and internal-combustion engines as apart from the boiler, or the means of gas production as mechanism converting the heat in the working fluid into indicated work, gives the steam efficiency as 23 per cent. and the gas efficiency as 35 to 37 per cent. If the boiler is included, the steam indicated efficiency falls to 19.6 per cent., and when the gas-producer efficiency of 85 per cent. is included, the gas engine indicated efficiency falls to between 29.8 and 31.4 per cent. and the brake efficiency to between 26.8 and 28.4 per cent. The table shows the comparison:

The law of similar structures and the experience of high-speed gas engines for aviation purposes all point to ultimate success in the construction of large gas-engine units composed of many cylinders geared to a common shaft. The writer speaks of a discussion of the principles of such engines with Sir Charles Parsons, and it was agreed that multiple-cylinder units of 10,000

STEAM AND INTERNAL-COMBUSTION ENGINE THERMAL EFFICIENCIES IN 1882 AND 1914

	Steam Engines		Internal-Combustion Engines	
	Thermal efficiency to heat of of steam supplied to engines		Thermal efficiency to heat of of gas supplied to engines	
Year	Indicated	Brake M.E. 90%	Indicated	Brake M.E. 90%
1882	12.7%	11.4%	16.0%	14.0%
1914	23.0%	19.5%	37.0%	33.4%
	Thermal efficiency to heat of coal supplied to boiler. Boiler efficiency, 85%		Thermal efficiency to heat of of fuel supplied to gas producer. Gas producer efficiency, 85%	
1882	10.8	9.7	13.6	11.9
1914	19.6	16.6	31.4	28.4

b.hp. on a single shaft are quite capable of practical construction on these lines. It requires only the design and development of a unit cylinder of about 250 b.hp. capacity at 250 r.p.m., and four 12-cylinder engines of this type could readily produce the required power in one shaft. Large-cylinder engines, such as had been developed in Germany before the war, do not permit of very large unit powers, except at an extravagant waste and cost. Such large-cylinder engines have no chance of competing with the steam turbine in the production of large units. At present the reciprocating gas engine is superior in fuel economy to the steam turbine, but it is probable that the large steam turbine may still improve in thermal efficiency. It is much to the benefit of both steam and internal-combustion industries that this rivalry should continue to exist, the steam-turbine engineers attempting to increase thermal efficiency and the interal-combustion engineer, the power magnitude of unit and thermal efficiency simultaneously.

There is a common error among some engineers as to the enormous heat loss in the cylinders, especially of a slow-running gas engine. The actual heat losses are much smaller than is generally supposed.

The following mean balance sheets of three separate indicator cards, taken by this method for determining heat loss and specific heat, show quite clearly that the heat flow during explosion and expansion is relatively low. The balance sheet is as follows:

MEAN BALANCE-SHEET

	Per Cent.
Heat flow during explosion and expansion	16.1
Heat contained in gases at end of expansion	49.3
Indicated work	34.6
	100.0

As here shown, the larger part of the heat loss is that discharged in the exhaust gases from the cylinder of the engine.

From the values it is evident that no great improvement in thermal efficiency would be obtained were the whole 16 per cent. heat loss of explosion and expansion entirely suppressed. Then 16 per cent. of 0.37 indicated efficiency would give only an addition of 5.9 per cent.; that is, the 37 per cent. would be raised at most to 43 per cent. This total suppression of heat loss is obviously impossible, but considerable improvement may be obtained by raising the compression ratio to 10. Here the air standard efficiency becomes 0.6, and assuming similar heat losses, $0.6 \times 0.7 = 0.42$; that is,

42 per cent. indicated thermal efficiency is practicable without reducing the heat loss to the piston and inclosing metal walls. In a multiple-cylinder engine mechanical efficiency may be taken as 90 per cent., so that the greatest probable brake efficiency would be 43 × 0.9, or 38.7 per cent.

Compounding in cylinders has been attempted many times, but the increased heat loss of transfer from high-pressure to low-pressure cylinder has rendered the gain in efficiency too small to be worth the additional weight and complication of the engine. There appears to be only one method open to further increase of heat economy in a practicable way, and that is by using regeneration of heat in some form. Utilization of the waste heat of the water jacket, and the heat of the exhaust gases, to raise steam, has become considerable. About 2.5 lb. of steam per brake horsepower have been obtained from the exhaust-gas heat of large gas engines. Many installations of this kind have been at work for about fifteen years. The steam generated has not been used for producing motive power, but for boiling and heating operations in chemical factories. If in such large installations the steam had been used in a high efficiency Parsons steam turbine requiring 10 lb. of steam per brake horsepower, then 25 per cent. would have been added by steam expansion to the brake power obtained by internal combustion.

In an engine giving 39 per cent. brake thermal efficiency, there remains 61 per cent. of the original heat of the engine part of which could be used to raise steam. Of these 61 heat units 4 are partly lost by engine friction and about 10 by radiation, so that the heat remaining for use is 61 minus 14, or 47; that is, 47 per cent. of the original heat. In a boiler of 80 per cent. efficiency this would enable 37.6 per cent. of the original heat of the gas to be delivered to a steam engine. Used in a Parsons steam turbine of 18 per cent. thermal efficiency, brake power to steam heat, would give an addition of 47 × 0.18, or 8.46; that is, the brake efficiency of one regenerative gas and steam engine would rise from 39 per cent. to slightly over 47 per cent. It may be taken that high-compression engines in large units with steam turbine addition might raise the brake efficiency to 47 per cent.

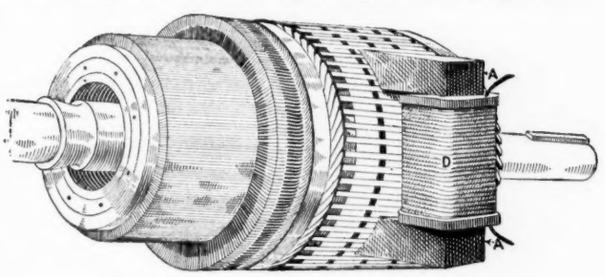
In considering the Diesel type, undoubtedly much further study and experiment are desirable. Little study has been given to Diesel indicator diagrams and less to the conditions of heat flow and exhaust loss. These should be very fully determined. Optical indicators should be used, and zigzag diagrams should be taken to determine specific heat and heat loss in the cylinder. Diesel efficiency is undoubtedly high, but by no means higher than can be obtained from constant volume or explosion gas engines when designed and built for high explosion pressures. The great problem in all Diesel engines is that of the formation and projection of all sprays. The spraying at present dominates the efficiency value obtainable.

The air standard efficiency shown on the Diesel type of diagram is 0.56. Assuming heat losses similar to those in explosion gas engines, the indicated thermal efficiency to be expected in the working engine would be 0.56 × 0.7 = 39.2; and assuming, as before, a mechanical efficiency of 90 per cent. in a multiple-cylinder engine, the brake thermal efficiency would be 39.2 × 0.9 = 35.3 per cent. With a compression ratio of 15, however, which is quite practicable in a Diesel engine, the air standard efficiency would be 0.62, and the indicated efficiency using the factor 0.7 would be 43.4, giving at 90 per cent. mechanical efficiency a brake thermal efficiency of 39 per cent. It is probable that in the case of Diesel engines the conversion factor will prove to be higher than 0.7 as the conditions of heat flow from fluid to cylinder are more favorable than in the explosion engine. Accordingly, it is to be expected that a combined high-compression and regenerative steam cycle will give brake efficiencies approximating 50 per cent., as in the case of the explosion engines.

Test Coil Burned Out

By E. C. Parham

For indicating the presence of short circuits in connected armature windings, some repair shops use a laminated iron shoe *A*, as shown in the figure, on which a coil *D* is wound. On applying the shoe to an armature as indicated with the coil connected to a source of alternating current and exploring with a strip of thin



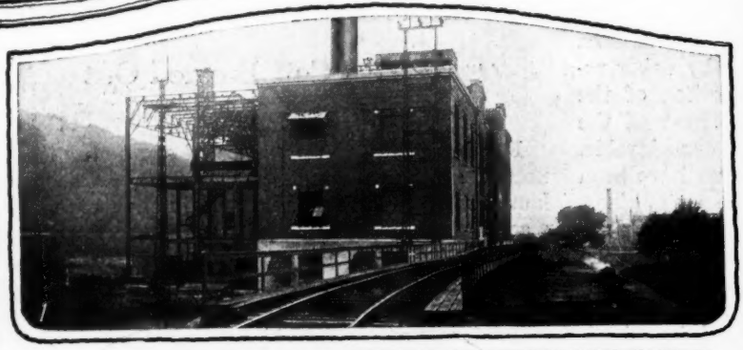
TEST COIL IN PLACE ON ARMATURE

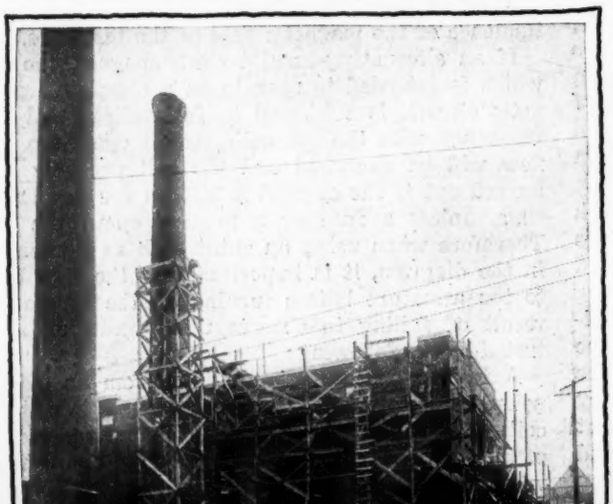
iron in the hand around the core while the current is on, the presence of a short-circuit will be indicated by the vibrating of the strip when it is held over one leg of the faulty coil, the other leg of which is within the influence of the magnetic field of the test shoe.

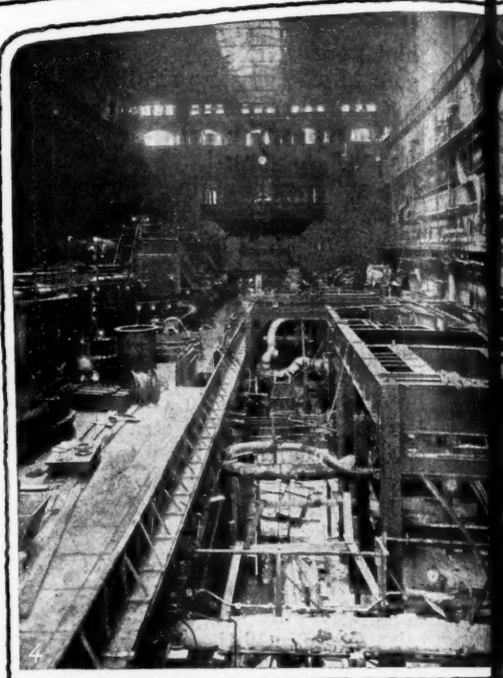
If an alternating-current electromagnet, the coil of which is intended to operate on a complete iron magnetic circuit, is subjected to full voltage and normal frequency with the magnetic circuit open, the current flow will be abnormal and the coil probably will be burned out if the current is left on for any length of time, unless a fuse or a breaker opens the circuit. Therefore when using an outfit such as that indicated in the diagram, it is important that the shoe be close to the armature before turning on the current. The result of failing to observe this precaution is illustrated by the following:

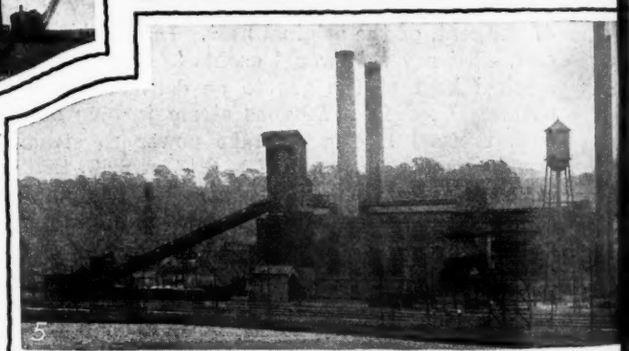
A testing shoe was improvised from an old motor polepiece onto which had been wound a coil. Two coils had been burned out but not before the usefulness of the shoe had been demonstrated. Assuming that the whole reason of the failures was insufficient space to put a proper winding, it was proposed to get special iron stampings from which to make a shoe that would permit of winding on a coil of a greater number of turns. However, about this time it was discovered that the cause of the coil burning out was due to allowing it to remain connected to the circuit when the shoe was not in contact with an armature core which caused the inductance of the coil to be low, consequently the current to be abnormally high. With due precautions that the electric circuit was closed only when the magnetic circuit was closed a similar coil gave no trouble.

SOME VIEWS ON









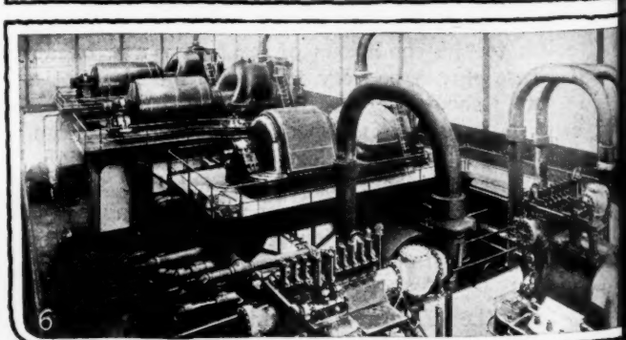
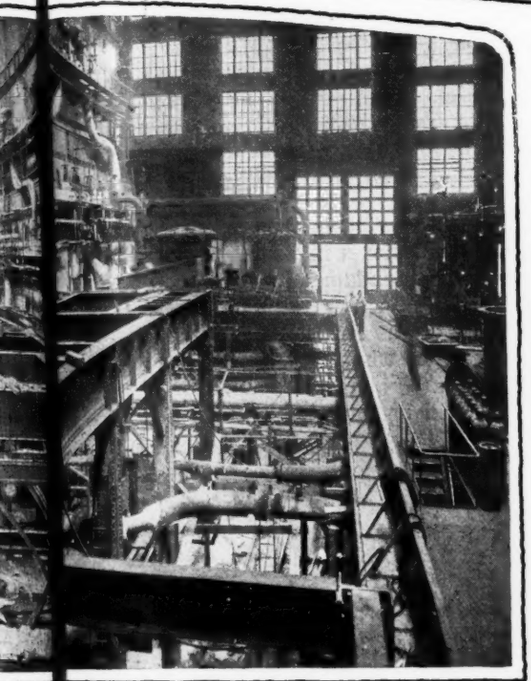
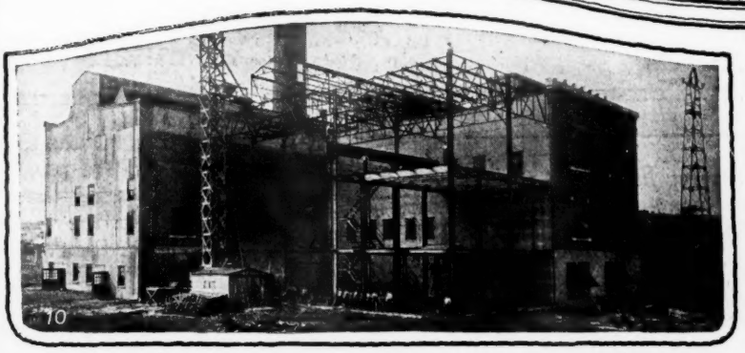
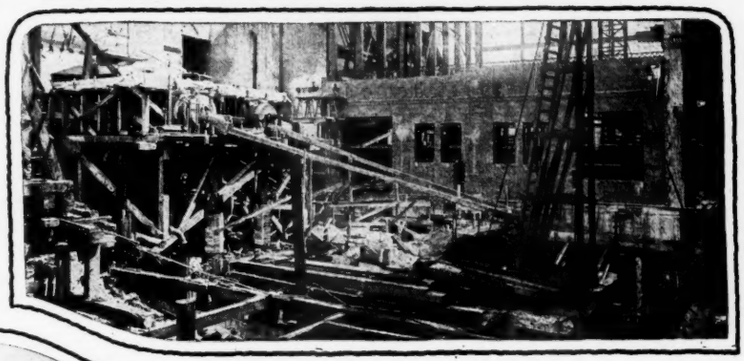


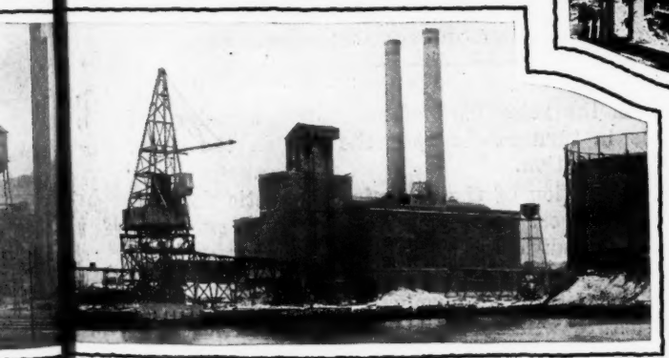
Fig. 1—Williamsburg (Pa.) Station, Penn Central Light & Power Co., Day & Zimmermann, Engineers.
Fig. 2—Front Street Station, Erie (Pa.) Lighting Co., Day & Zimmermann, Engineers.
Fig. 3—Nicholas & Shepard Co., Battle Creek, Mich., Westinghouse, Church, Kerr, Engineers.
Fig. 4—Foundations for New 35,000-kw. Turbines, Waterside No. 2 Station, New York Edison Co.
Fig. 5—Lowellville (O.) Station, Mahoning & Shenango Ry. & Lt. Co., Stone & Webster, Engineers.

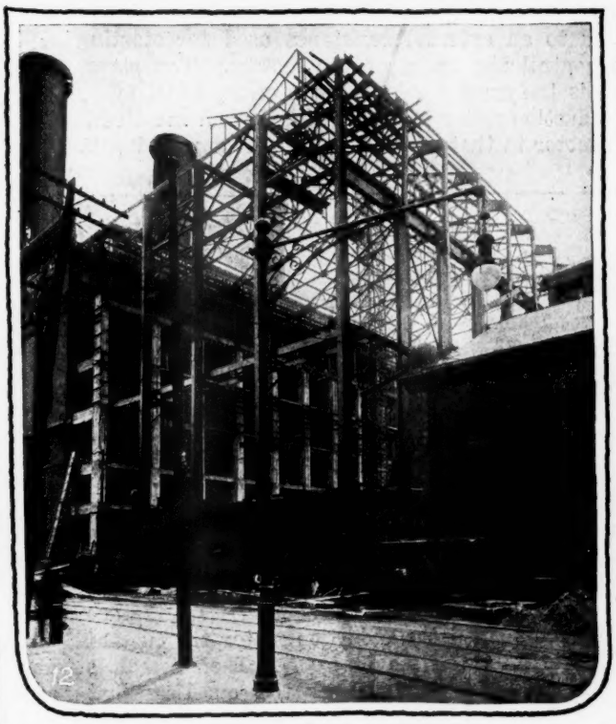
NEW POWER PLANTS











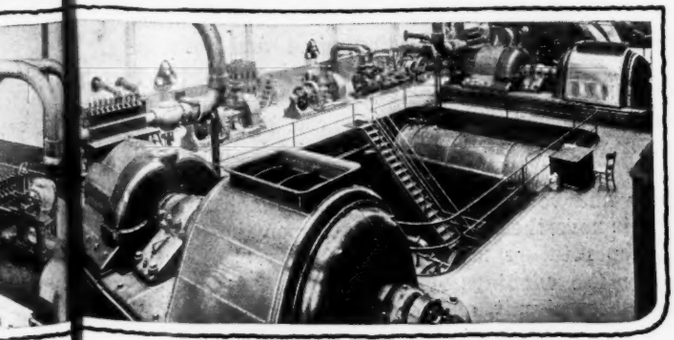
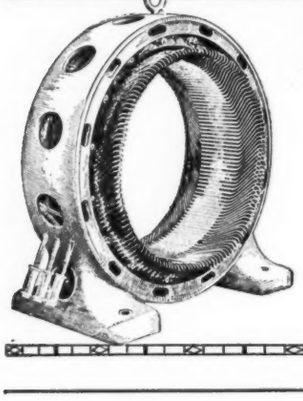
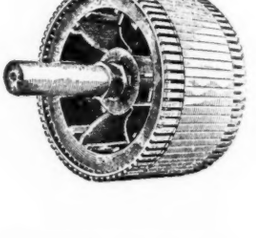


Fig. 6—New Bedford (Mass.) Gas & Edison Lt. Co., Stone & Webster, Engineers.
Fig. 7—Looking East, Waterside No. 2 Station.
Fig. 8.—New Bedford Gas & Edison Light Co.
Fig. 9—Mahoning & Shenango Ry. & Lt. Co.
Fig. 10—Penn Central Lt. & Power Co.
Fig. 11—Williamsburg Annex, Brooklyn Rapid Transit Co., Thomas E. Murray, Engineer.
Fig. 12—Williamsburg Annex, Front View, Two 35,000-Kv.-a. Turbines, Three Units Going in Later.



The Rotating Magnetic Field in Alternating-Current Motors

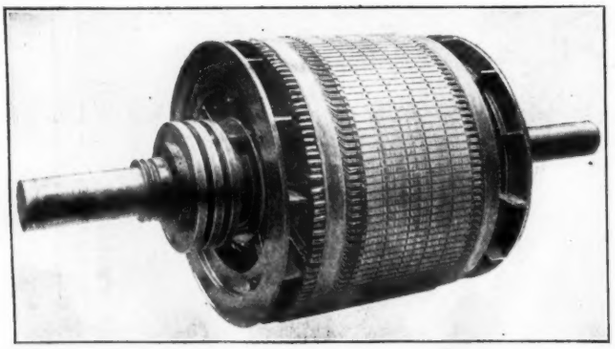


by
F. A. Annett

There are in general use two types of polyphase alternating-current motors; namely, induction and synchronous. Both operate on the well-known revolving magnetic-field principle. It is the purpose of this article to explain how the revolving magnetic field is produced.

INDUCTION motors are made up of two major parts, the stator and the rotor. The stator, shown to the left in the headpiece, is the stationary element and has placed in slots, in the inner periphery of the core, coils which are grouped into a winding connected to the power circuit. The rotor of the squirrel-cage type is built up of a laminated iron core, slotted on its outer periphery. In these slots are placed copper bars which are connected to rings at each end of the core, thus forming a closed winding, as shown to the right in the headpiece. In the wound-rotor type the revolving element is wound with an insulated winding and connected to slip rings, Fig. 1, similar to the winding used on a revolving-armature-type alternator. The slip rings are connected to an external resistance used for starting and to control the speed of the motors. The stator winding is the same for both types of machine.

The induction motor is differentiated from the direct-current motor in that where the latter is supplied with



WOUND ROTOR FOR INDUCTION MOTOR

current from an outside source to both its armature and field windings, in the induction motor the current is supplied to its stator winding only. Then how does the induction motor operate? is the question that naturally arises. This might be answered by saying, "On the same fundamental principles as the direct-current motor"; namely, the reaction between the magnetic field set up about the conductors on the revolving element due to the current flowing in them and the flux from the polepieces, the polepieces in the induction motor being the stator. The fundamental difference between the two machines is in how the current is set up in the rotor winding of the induction motor, which has no electrical connection whatever with the stator winding. In what follows in this and a subsequent article, an explanation will be given of how current is

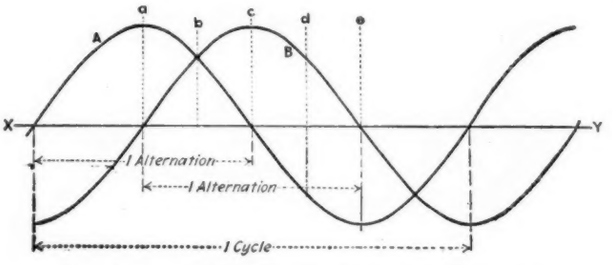


FIG. 2. CURRENT OR VOLTAGE CURVES OF A TWO-PHASE CIRCUIT

induced in the rotor bars of an induction motor and how this in turn reacts upon the flux in the stator to produce rotation.

The explanation of the revolving magnetic field can in general be most easily given by utilizing a two-phase circuit, the conditions of which may be represented by the curves *A* and *B*, Fig. 2. Instead of using a smooth-bore stator with a uniformly distributed winding, a field structure will be employed similar to that used in a direct-current machine (see Figs. 3 to 7). In this structure there are eight polepieces, four of which are linked together by the winding *A* and four by winding *B*, representing the conditions in a two-phase motor. Although there are eight polepieces, it will be seen in the following that the magnetic lines combine in such a way as to form but four poles. In this discussion it will be assumed that the current is in step with the voltage, although this is not true in practice; it nevertheless has no effect upon the production of the rotating magnetic field.

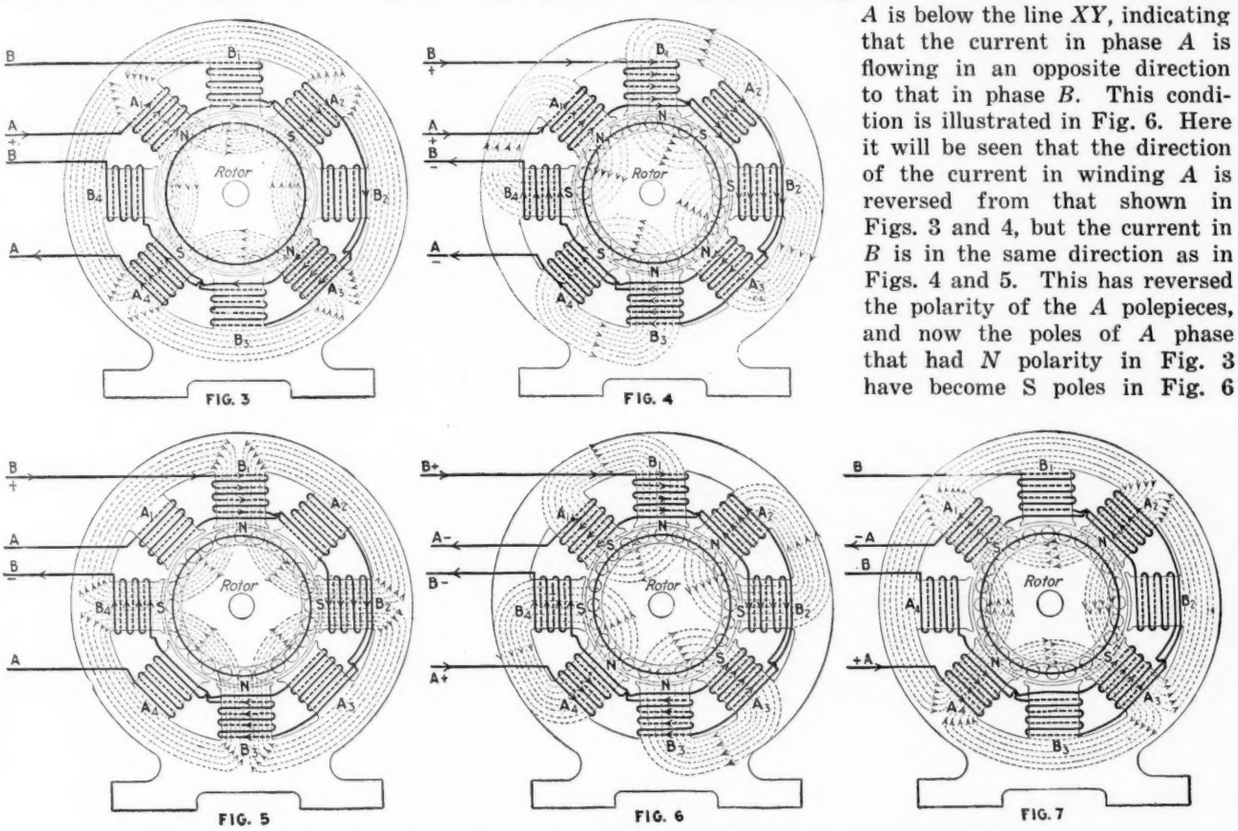
Consider the windings *A* and *B*, Fig. 3, connected to a two-phase circuit, and let curve *A* and *B*, Fig. 2, represent the voltage applied to the windings, consequently the current flowing in them. At the instant *a* on the curves, Fig. 2, it will be seen that the voltage in phase *A* is at a maximum value, while that in *B* is at zero, consequently the current in winding *A*, Fig. 3, will be at a maximum value. If the current is considered flowing in winding *A* in the direction of the arrowhead, poles A_1 to A_4 will be magnetized of a polarity as indicated. Since the current is at a maximum,

the magnetic field will also be at a maximum value and will divide at the center of the N poles, pass into the rotor core back into the S poles, as illustrated in the figure. This division of flux at the pole faces is similar to that in the bar magnet, Fig. 8. Here the flux also divides at the center of the N pole and passes around through the air to the S pole.

Next consider the condition in the circuit represented by the instant *b* on the curves, Fig. 2. At this instant the current in *A* has decreased and that in *B* increased until it is the same value in both. Applying this condition to the motor windings, the current will be one-half maximum in each and in the same direction as in Fig. 4. This arranges the eight poles into four groups, each containing two like poles. Like poles repel, therefore all the flux from any N pole will pass into the rotor core and go to the adjacent S pole, as shown in Fig. 4. This condition is illustrated with bar magnets in Fig. 9. Here the two similar magnets *A* and *B* are placed so that their like poles are adjacent to each other, and since like poles repel, the flux from one N pole will be pushed away from that of the other, consequently giving a distribution to the lines of force similar to that shown in the figure. Comparing Figs. 3 and 8 with Figs. 4 and 9, it will be seen that where the centers of the magnetic fields are at the centers of *A* polepieces in Figs. 3 and 8, the centers of the magnetic field are located between *A* and *B* polepieces in Figs. 4 and 9. In other words, the center of the magnetic field has been caused to move one-half the width of a polepiece.

At the instant *c*, Fig. 2, the current in phase *A* has decreased to zero, and that in phase *B* has increased to a maximum value, consequently the current in the motor's winding *A* will be at zero value, while that in winding *B* will be at a maximum value. This condition is illustrated in Fig. 5. The flux in the *A* polepieces has become zero, while that in polepiece *B* has reached a maximum value, and the center of the magnetic field is at the center of the *B* polepieces. This condition is the same as if bar magnet *A*, Fig. 9, was removed. Then the flux distribution would be as indicated in Fig. 10, which shows the center of the magnetic field shifted to the left from between *A* and *B* magnets, in Fig. 9, to the center of the *B* magnet, Fig. 10. Again, the center of the magnetic field has been caused to shift one-half the width of a polepiece.

Returning to the curves *A* and *B*, Fig. 2, and considering instant *d*, it is found that the currents in *A* and *B* phases are again of the same value. But curve *A* is below the line *XY*, indicating that the current in phase *A* is flowing in an opposite direction to that in phase *B*. This condition is illustrated in Fig. 6. Here it will be seen that the direction of the current in winding *A* is reversed from that shown in Figs. 3 and 4, but the current in *B* is in the same direction as in Figs. 4 and 5. This has reversed the polarity of the *A* polepieces, and now the poles of *A* phase that had *N* polarity in Fig. 3 have become S poles in Fig. 6 and vice versa. However, this has again brought like poles adjacent, and the flux distribution will be as shown. This is a condition similar to what would have been the case if magnet *A*, Fig. 9, had been taken from the left-hand side of the *B* magnet and placed on the right-hand side as in Fig. 11. Again the center of the magnetic field has shifted, this time from the center of the *B* polepiece to between *B* and *A* polepieces.



FIGS. 3 TO 7. SCHEMATIC DIAGRAMS OF A TWO-PHASE INDUCTION MOTOR

At instant *e* on the curves, Fig. 2, the current in phase *B* has decreased to zero, and that in phase *A* has reached a maximum value. This is a condition similar to that existing at instant *a*, excepting that the direction of the current in phase *A* is reversed. Consequently, the current in the motor winding will be zero in phase *B* and at a maximum value in phase *A*, as in Fig. 3, therefore the magnetism in pole *A* will be at a maximum and in *B* zero value, Fig. 7. This will give a flux distribution the same as that in Fig. 3, but of a reverse polarity. The center of the magnetic poles has now shifted from between the *B* and *A* poles.

Fig. 6, to the center of the A poles as shown in Fig. 7. A similar condition would be obtained in Fig. 11 if magnet B is removed as in Fig. 12. There the center of the magnetic field has shifted from between the B and A magnets to the center of magnet A.

Comparing Fig. 8 with Fig. 12, it is seen that the center of the magnetic field has shifted from the center of magnet A, Fig. 8, shown in dotted line in Fig. 12, to the center of magnet A, shown in full lines, Fig. 12. Similarly in Figs. 3 to 7, the magnetic field has shifted from the center of magnets A_1 and A_3, maximum value N poles, to the center of A_2 and A_4, maximum N poles; likewise the S poles have shifted from A_2 and A_4 to A_1 and A_3.

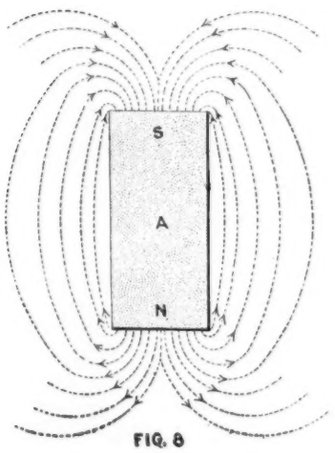


FIG. 8

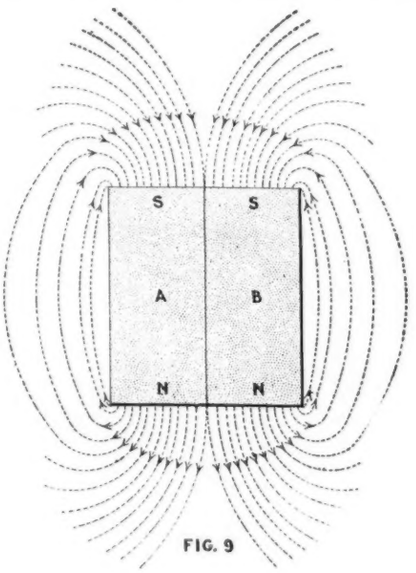


FIG. 9

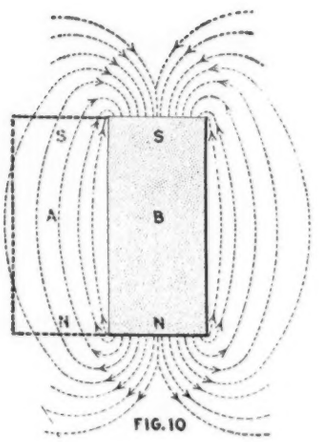


FIG. 10

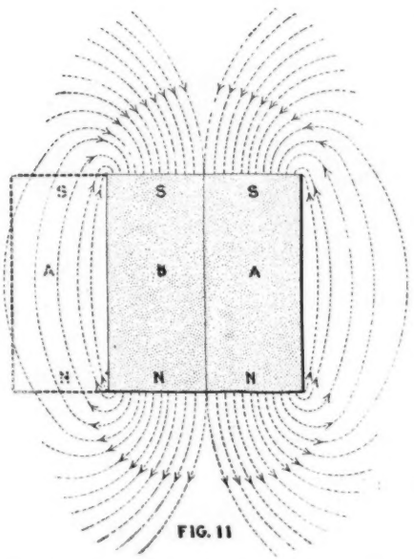


FIG. 11

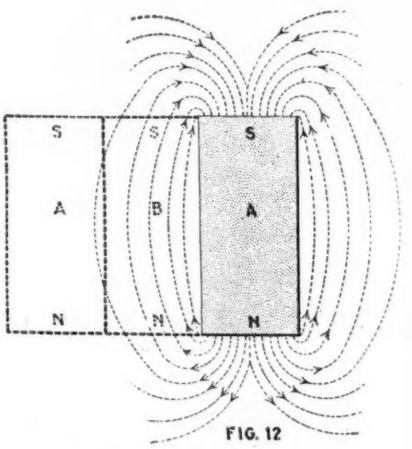


FIG. 12

FIGS. 8 TO 12. ILLUSTRATES HOW THE MAGNETIC FIELD IS MADE TO REVOLVE IN AN INDUCTION MOTOR

Referring to the curve, Fig. 2, it will be seen that the current in each phase has passed through the equivalent of one alternation. At a the current in phase A is at a maximum, and that in phase B is at zero value; likewise at e phase A is again at a maximum value, but in this case in the opposite direction, and phase B is at zero. From this it is evident that for one alternation the magnetic field in the motor shifts one pole, then for one cycle (two alternations) the magnetic field will shift two pole spaces. In other words, for each cycle that the current passes through, the magnetic field will shift around the one pair of poles. Now, if the motor was connected to a 60-cycle circuit—that is, a circuit in which the current makes 60 complete reversals per second, or 120 alternations per second—the number of revolutions made by the magnetic field in one second would equal the cycles divided by the pair of poles. In our problem the induction motor has four poles, or two pairs, therefore the speed per second of the magnetic field for a 60-cycle circuit will be $\frac{60}{2} = 30$ revolutions. Looking at this problem another way, for one cycle the field will shift two pole spaces; therefore, for two cycles, in a four-pole machine, the field will shift four pole spaces or make one revolution; that is, two cycles is equivalent to one revolution. Then for 60 cycles the field will make $60 \div 2 = 30$ revolutions, which checks with the value obtained in the foregoing.

In one minute the speed will be 60 times that for one second, or in this case, $30 \times 60 = 1800$ revolutions per minute. If S equals the revolutions per minute, $\frac{P}{2}$ the number of pairs of poles, and f the frequency, the cycles per second, then the revolutions per minute S—that is, the speed of the magnetic field—is $S = \frac{120f}{P}$. Substituting the value 60 for the frequency (cycles per second) and 4 for the number of poles gives $S = \frac{120 \times 60}{4} = 1800$. If the frequency were only 25 cycles per second, $S = \frac{120 \times 25}{4} = 750$ revolutions per minute. From this it will be seen that if a 4-pole motor is connected to a 60-cycle circuit, its magnetic field will revolve at 1800 revolutions per minute, and on a 25-cycle circuit, 750 revolutions per minute.

The formula may be transposed to read $P = \frac{120f}{S}$ to find the number of poles when the speed and frequency are known, and $f = \frac{PS}{120}$ to determine the frequency (cycles per second) when the number of poles and speed are known. If the frequency equals 60 cycles per second and the speed 1800 r.p.m., then $P = \frac{120 \times 60}{1800} = 4$ poles. This is what it should be for the machine in the figures. On the other hand, knowing the number of poles to be 4 and the speed to be 1800 r.p.m., frequency $f = \frac{4 \times 1800}{120} = 60$ cycles per second. From this it is evident that there is a fixed relation between the number of poles and the speed of the revolving magnetic field of an induction motor and the frequency of the circuits to which it is connected. From this it is evident that there is a fixed relation between the number of poles and the speed of the revolving magnetic field.

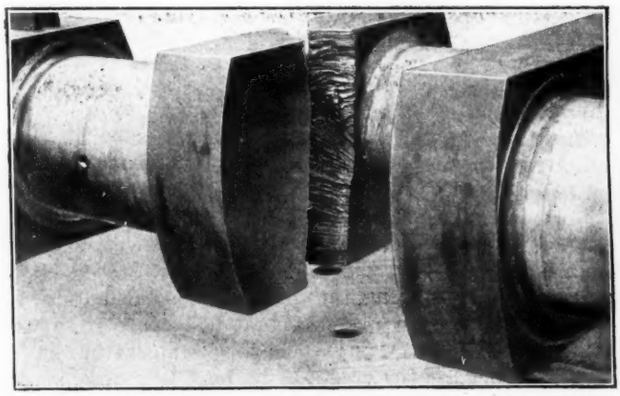
An Unusual Welding Repair Job

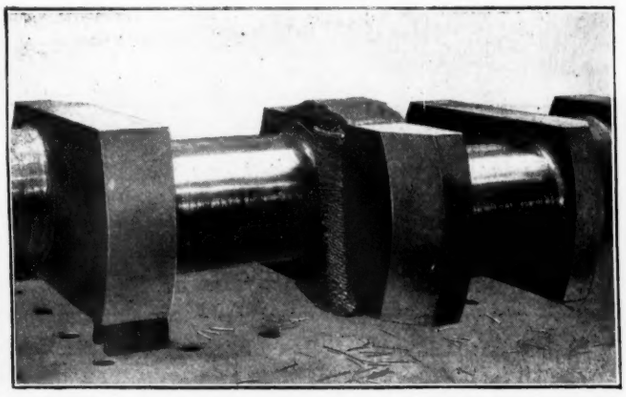
An unusual welding repair job, which required skill to successfully handle, was that of a six-ton crankshaft broken through the web, as shown by Fig. 1, which view was taken after the surface of the break had been chipped preparatory to welding.

This shaft was part of the equipment of the Houston Ice Brewing Co., Houston, Tex., but as repairs could not be made in that section, the broken shaft was shipped to the Jersey City plant of the Vulcan Iron Works, where it was electrically welded by the Wilson plastic-arc process.

The greatest difficulty was insuring proper alignment of the shaft at the conclusion of the work. The shaft was clamped to the table, and lined up as shown in Fig. 3, and the welding proceeded after the metal at the break had been chipped out to insure a clean surface for the added welding metal to fuse with.

The finished job is shown in Fig. 2. The shaft was then tested in a large lathe and found to be true from end to end.





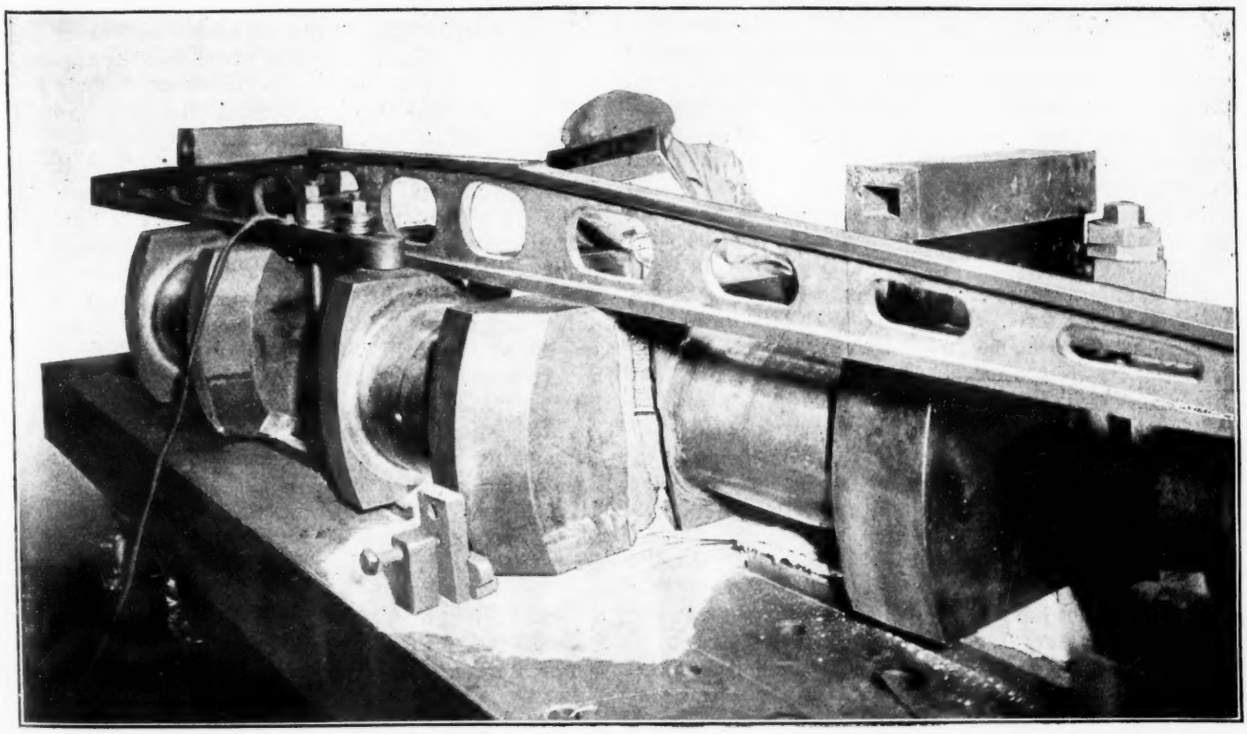
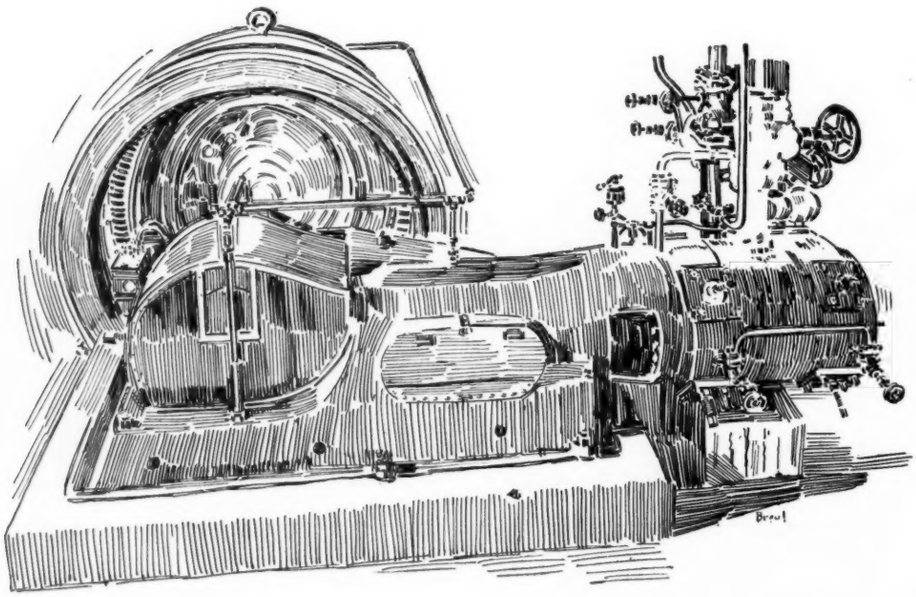


FIG. 1. CHIPPED SURFACE OF BREAK, BEFORE WELDING. FIG. 2. THE COMPLETED JOB BEFORE TRIMMING.
FIG. 3. THE SHAFT LINED UP AND CLAMPED TO THE TABLE; WELDING IN PROGRESS

FUNCTIONS OF AMMONIA COMPRESSOR



By

John E. Starr,

CONSULTING ENGINEER

NEW YORK

Rid the mind of the idea that the compressor sucks the gas into its cylinder from the evaporating coils; it comes in under pressure, and the higher the pressure the better. Wet compression is no help to power consumption per ton capacity. Watch the jacket water temperature.

WE have seen that the expansion system, whether it be pipes or a cooler, may be likened to a steam boiler as it generates gas or changes a liquid to a gas by boiling on adding heat to it at a low pressure.

The suction pipe of the evaporator should be regarded as one regards the pipe carrying steam to the engine.

Rid the mind of the idea that the compressor "sucks" the gas from the evaporator. Consider it the other way; get it firmly fixed in the mind that the heat added in the evaporator boils a liquid into a gas just as heat boils water into steam and that this gas is delivered to the compressor with some pressure and helps to run it.

For example, suppose the boiling point in the evaporator is about zero. It will boil the liquid into a gas at a pressure of about 30 lb. abs. or 15 lb. gage and deliver it to the suction side of the compressor at that pressure. If the head pressure is 175 lb. above no pressure, or 160 lb gage, the net pressure is 175 — 30 = 145 lb. or by gage 160 — 15 = 145 pounds.

The steam engine or other motive power then has to compress the gas from 15 lb. gage to 160 lb. gage in order to put it in shape to condense back to a liquid having a temperature of about 84 deg. F. in this case. If the cooling water was zero or a little below, this power would not have to be applied, for the gas flowing to the compressor at zero would condense back to a liquid at 15 lb. gage pressure and could be boiled again.

But there is no water at zero. If there was, no compressor would be needed there. There may be water that can be heated to about 84 deg. F. So the gas at zero must be made to condense at 84 deg. This can be done by adding a little heat or power to the power that is already in the gas and then, by taking some heat out of it, condense it to a liquid at 84 deg. So heat or power is added in this case, by 145 lb. pressure in addition to the 15 lb. gage pressure it already has, and so 160 lb. gage pressure is produced at which the gas will condense to a liquid at 84 degrees.

But in compressing the gas heat is added to it, so that while it has a pressure that will cause it to condense at 84 deg. F., it will have a temperature much above 84 deg. at the start. This heat is called "superheat," meaning that the gas is heated above its condensing temperature. This superheat has never been saved. Theoretically, it can be saved, but the apparatus to save it would not pay except in an enormously large machine, so this heat is rejected and sent away by radiation and in the cooling water.

Not only does the heat of compression heat the gas itself, but the heat of the gas is conveyed to the cylinder walls. The heat from these walls in turn heats the incoming gas that has been driven by the evaporator to the compressor. This expands the incoming gas so that it occupies a little more space per pound, or any unit weight, than it did at the temperature at which it was boiled out; or in other words, if a pound of ammonia at zero was boiled well, the resulting gas would occupy 9.18 cu.ft.; but as this gas becomes expanded by cylinder heating, it would occupy from 11.5 to 12.2 cu.ft. in the compressor. So to cause the evaporation of 1 lb., or 9.18 cu.ft., boiled at zero one really has to displace from 11.5 to 12.2 cu.ft., and to add 145 lb. pressure to it to condense it at 84 deg. F. This is called volumetric efficiency, which simply means that the compressor displaces only from 75 to 80 per cent. of the weight of liquid changed to a gas at, say, zero. It is true that by injecting a little liquid ammonia at the compressor one can take out some of this superheat; but it must be remembered that this liquid in order to cool, must also be changed to a gas and that this gas must be handled by the compressor. Therefore "power per ton" has not been helped much by "wet" compres-

sion. Nor can much be expected from water jackets. In a single-acting machine the gas enters colder than the water and gets warm only by heat transferred to it after the discharge valve has opened, so about all the jackets do is to help out the condenser. In a double-acting machine the conduction of the iron brings out about the same results, and the principal advantage in wet compression lies in the fact that it lowers the temperature of the gas somewhat while in the compressor and keeps the oil and the stuffing-boxes cooler than they would be otherwise.

It was shown clearly in the celebrated Eastman Kodak tests that it made little difference in horsepower per ton whether the water was running in the jackets or not, and it was also shown that the water was cooled instead of heated at the inlet side of the compressor. So best results have been obtained by so feeding the liquid that the gas is all boiled out and comes to the compressor only a little above the temperature at which it boiled.

It should come to the compressor a little above the temperature at which it was boiled so as to be sure that no liquid enters the compressor. It is easy enough practically to keep it, say, 5 to 8 deg. above the boiling point. The return pipe may frost, but frost is no indication that liquid is present, for in our experiment with the glass (see *Power*, July 22, p. 142) we have seen that the gas is capable of taking up a little heat at low temperature and frost will appear a very little way above the liquid. In a small suction pipe a lot of cold gas may frost the pipe before it gets above 32 deg. So do not look at the pipe; look at the thermometer, which should always be in a suction pipe near the compressor.

If the thermometer indicates a temperature of, say, 5 or 8 deg. above the boiling point in the evaporator, one can be sure no liquid is projected. If the compressor is double-acting, also watch the thermometer, and inject on the compressor side only enough liquid to keep the stuffing-boxes in good order. Having done this watch the compressor and see that unnecessary power is not used to move the suction and discharge valves and that gas once compressed does not slip back, to be compressed again.

A picture of what is going on in the compressor can be had by an indicator. The use of the latter instrument has been ably described by others, also the inferences that may be drawn from the "pictures" produced by it. [For an excellent series on indicating the ammonia compressor, see *Power*, April to September, 1916.]

The gas in the suction of the compressor is really produced from a liquid by heat taken up in the refrigerator, and this gas is driven to the inlet of the compressor with some pressure as compared to no pressure. The compressor is only a machine for adding heat in the shape of power, to build up the pressure so that one can use it on dropping down just as one boosts water up into a reservoir for convenience—so one can use it when it flows down.

This use is either in the form of refrigeration direct or in making storage batteries; that is, ice which can be subdivided in large or small lots.

Priorities Between Inventors

By CHESLA C. SHERLOCK

THE rapid development of many phases of our industrial life, particularly in regard to its relation to the resumption of commerce by the nations of the world, has given a new interest to the patent laws and their application to specific cases.

The question of priorities between inventors has always been one of more or less interest, but it is especially valuable to be well informed upon the subject at this time. With the commercial and industrial interests everywhere "upon their toes," as the expression goes, competition will be no less acute in the matter of obtaining patents than in the matter of capturing markets.

It is a fundamental proposition that he who first reduces an invention to practice is *prima facie* entitled to be deemed the inventor thereof. This does not necessarily mean that he must have originally conceived the root idea or to have worked out everything pertaining to his invention. The courts, particularly the United States Supreme Court, have repeatedly said that they will sustain the patents of those who turn failures and unsuccessful experiments into success. This does not, in turn, mean that one who has conceived the original idea can be robbed of his just reward by a skillful mechanic or engineer who, by reason of his learning and skill, can quickly change a few details and snatch success from the jaws of defeat. It is likewise a well-recognized principle that the person who conceives the original idea is entitled to be considered the inventor of the invention, provided he uses reasonable diligence to adapt it to practice.

The matter of what is "reasonable diligence" has a great deal to do with determining the question of priorities between rival inventors. The prior right always rests with the actual inventor, but he may by his conduct deprive himself of this right even though he did in fact produce and perfect the invention. The courts have said that the inventor may tarry a while in order to experiment with his invention before making an application for a patent, but he is allowed only a reasonable time in which to experiment. If he delays beyond that "reasonable time," he loses his right to priority. The question of what is a reasonable time must, of course, depend upon the circumstances surrounding each case.

It has also been held quite generally that if the actual inventor purposely conceals his invention from the public and takes no steps to assert his rights under the patent laws, he cannot, if in the interval another brings out the invention and patents it, step in and attempt to restrict the latter from enjoying such patent. And it is the settled rule both in the United States and in England that he who first applies for and obtains a patent will be protected by the courts and his rights given priority over another claiming to be in fact the true inventor. This rule may be subject to some modifications, as in case of fraud, but it is so overwhelmingly general as to be settled. Delay on the part of the true inventor in making application is also attended with a great deal of risk, and if losses occur, they too often fall upon the inventor himself. He, of course, has common-law rights, but they are generally extinguished upon the granting of a patent.

Dispatch and diligence in applying for a patent can

not be too strongly urged upon all who have invented designs, appliances or machines. Only by the utmost diligence and speed can the true inventor acquit himself of the imputations that always follow a delay.

The Relations of Employers and Employees

As between employers and employees many questions, not only of interest but of value, arise where patent rights are concerned. Contrary to the general opinion the mere contract of employment does not give the employer the right to all inventions made by the employee. This is true even in cases where the work is done on the employer's time, where the aid of other employees is used, and where the employer's own materials are used to complete the invention.

The point to be kept in mind is that law seeks to secure to the *inventor* all the rights and privileges conferred by the patent laws and not to secure them to one who may morally be entitled to them. An ordinary contract of employment, then, will not give the employer a prior right to the invention, even though he is entirely responsible for the successful completion of it. However, where the employer himself is the originator of the idea and of the scheme for the invention, but hires someone else to do the work necessary to perfect it, a different situation arises. In this case the employer is deemed to be the rightful inventor and consequently is entitled to the prior right to the invention.

In like measure, if the employee is the originator of the idea or scheme that makes the invention possible, the employer cannot come in and appropriate it and take out a patent. The employee is the inventor, and he has a prior right to the invention and to the patent.

Some very interesting cases have been decided upon the rights of employers and employees to patents, but they are interesting in the present discussion only in so far as they apply to the question of who has the prior right. Strictly speaking, unless the employer and the employee are equally inventors or originators of the plan, both cannot be considered as inventors. The real inventor of the two has the prior right in ordinary cases.

These considerations should not be confused with cases where a workman has entered into a contract to *assign* his patent rights upon such inventions as he may successfully complete. They revolve around entirely different conditions.

Foreign Patents Not Always Desirable

There is a particular interest at this time in foreign patents, and this interest will no doubt be greatly intensified in the next few years.

Generally speaking, a foreign patent may not be of any value to an American inventor unless he is prepared to quickly follow it up with active foreign trade. If he intends to market his invention entirely in the United States, he would in most instances be better off to confine his patent activities to this country, because the mere holding of a foreign patent may greatly restrict his rights under our own patent laws.

The Act of July 8, 1879, provided that a United States patent for an invention "previously patented in a foreign country" would expire when the foreign patent did. It further provided that if there were more than one foreign patent the American patent would expire when the shortest one did, and in no case to run for more than 17 years.

What does this art mean to a citizen of this country?

In one instance, it means that if an American applies for a patent from the United States Government, then applies for a foreign patent and the foreign patent is granted before the American patent, his American patent will be limited by the foreign patent.

If his foreign patent is for a term of years less than that granted on domestic patents, he will lose just that much by taking out his foreign patent. The question of advisability in taking out a foreign patent hinges, then, upon a determination of which will be the most profitable to the inventor—protection abroad, or domestic profits for the full term guaranteed under the United States patent laws. Of course, where the inventor is prepared to market his invention in the foreign country where he seeks patents, a different matter arises.

It is not necessary, according to the courts, for the United States patent to be expressly limited on its face to the term of years for which the foreign patent limiting it is to run. The courts have also held, in relation to this matter, that "a patent for an invention does not expire at the same time with a foreign patent for the same invention unless the foreign patent was obtained by the American patentee or with his consent."

The Act of Mar. 3, 1897, which amended in some particulars the earlier act, was such as not to affect the life of a domestic patent granted on an application filed on or after Jan. 1, 1898, to the life of a prior foreign patent, provided that the application for the domestic patent was filed within seven months from the filing of the foreign patent.

How a Large Power Plant Was Kept in Service

By L. W. Wyss

In a large hydro-electric station there were two three-phase transformers which stepped the generator-bus voltage of 5000 down to 210 and 122 volts for station power and lighting. A burn-out in one transformer did not cause any inconvenience, as it was quickly disconnected from service and the remaining transformer had ample capacity to handle the station power and lighting load. However, before new coils could be secured for the burnt-out transformer, the other one failed. The burn-out of each was so severe that repairs were impossible without obtaining coils from the manufacturers.

Conditions were now very serious, as no source of power was available to drive the motor-driven station auxiliaries. The most important auxiliaries were the high-tension transformer circulating-water pumps and the governor oil-pressure pumps. Since the high-tension transformers were loaded to very near their capacity, it would perhaps be only about an hour before they would overheat and the greater part of the load would have to be dropped. The hydraulic governors were useless without the oil-pressure pumps in operation, therefore the only thing to do was to connect the handwheel control to the turbine gate shafts, which was done at once. With handwheel control the speed and voltage regulation was poor under normal load conditions, but was better than a shutdown. In the event of a storm causing short-circuits on the transmission lines and resultant sudden loss of load, this method of operating was extremely hazardous because it was impossible for the operators to close the gates fast enough

to prevent dangerous racing of the large hydro-electric units.

The station chief was present at the time, and he immediately helped the turbine operators and wipers to put the machines on handwheel control. Men were stationed at four of the six turbines which were running at this time.

During the time the change over was being made, the switchboard operator had called the two reserve steam stations, which were combined with the substations in

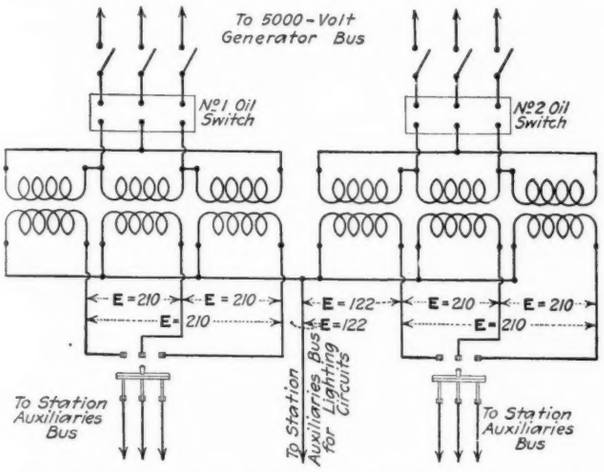


FIG. 1. SHOWS HOW THREE-PHASE TRANSFORMERS WERE CONNECTED

two cities at the receiving end of the two 120,000-volt transmission lines. The boilers were fired at once at these stations, but it is doubtful if they could have relieved the hydro-electric plant of the load before the transformers would have heated to their limit. The switchboard operator then called the other available station operators who were off shift, thinking that they would be of assistance.

The big problem was how to provide cooling water for the transformers. Gravity feed from the forebay was impossible as the transformers were higher than the head-water elevation. It was realized that some scheme must be devised to drive one of the triplex circulating pumps. These pumps were belt-driven and in duplicate, either being capable of pumping enough water for cooling purposes. They were located behind two of the generators, and it would take considerable time to set up any temporary drive that would connect a pump to a generator shaft. The chief was still studying this problem when one of the operators that was off shift arrived in his automobile. After a brief discussion the latter remarked that he thought his car could drive the pump if there was any way to get it in position, which would be difficult, because there was not room to take it in between the generators. The traveling crane solved this part of the problem. The car was driven into the plant as far as possible, then using the crane it was lifted high enough to clear the generators and set down near one of the pumps. One rear wheel was blocked while the other was lined with the pulley of the pump and the tire taken off. After splicing the two pump belts to make one long enough to reach, the car was ready to drive the pump. While it did not work very smoothly, it was good enough to rely on for a short time.

While this work was being done the chief thought of a plan to obtain power for the station auxiliaries. The station transformers that were burnt out were connected as shown in Fig. 1, 210 volts being available for motors and 122 volts for lights, the latter being taken from one phase and neutral.

The station contained three banks of single-phase transformers and a spare, the former stepped the voltage from 5000 up to 120,000 and were connected delta, to delta. A little figuring showed that the ratio was 1 to 24, and dividing 5000 by 24 indicated that by connecting 5000 volts to the high-tension terminals the resultant voltage at the low-tension terminals would be about 208, which would be satisfactory for the station auxiliaries.

If an entire bank of these power transformers were used for this purpose, there would not have been sufficient capacity in the other two to handle the load for any great length of time. It was then decided to take one bank out of service long enough to disconnect the low- and high-tension terminals of one transformer. This left the two other units connected in open delta, and when again placed in service they were capable of handling only 57.7 per cent. of the load which three units could handle. This, however, was sufficient to handle the load that this bank of transformers supplied. Some insulated cables were then used to connect the transformer taken from the bank and the spare unit in open delta, as shown in Fig. 2. Power was now available to drive the transformer cooling-water pumps and governor pumps. For the 122-volt lighting in the station some temporary wiring was done to connect the lighting circuits of the station to the 125-volt exciter bus.

By referring to the switchboard operator's records, it was found that the burn-out happened at 11:14 a.m.,

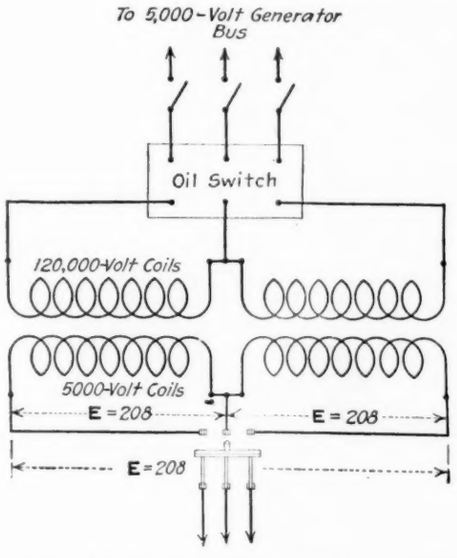


FIG. 2. TWO TRANSFORMERS CONNECTED OPEN DELTA

the automobile was driving the transformer cooling-water pump at 12:25 p.m., a steam turbine was on the line at one of the steam plants at 12: 57 p.m. to take care of the load variation, and at 2: 20 p.m. the temporary transformer connections had been made and the hydraulic governors were again in service. There were no service interruptions whatever. During the time that the high-tension bank of transformers were out of service, a tie switch was closed, which allowed the other two banks to handle this load.

Failure of Diesel-Driven Alternators to Parallel

By D. L. FAGNAN

AFTER giving fine service for almost a year, an electric-light plant containing two 16 x 24-in. Diesel engines driving alternators suddenly developed trouble through irregular running and thumping of one of the engines, causing the alternators to fail to parallel. The engines were of the three-cylinder vertical type, ran at a speed of 164 r.p.m. and developed 225 hp. each.

Normally, only one engine was used, but as the load came on, the other was put into service. The faulty operation that resulted was an annoyance because the plant had no reserve capacity and both engines were needed to carry the peak loads. As a consequence part of the load had to be dropped until the trouble was remedied, which was a serious matter in an electric-light plant.

There was no particular trouble under light loads, except that the middle cylinder of one of the engines had a muffled thump. This was detected by touching the cylinder with a lead pencil gripped firmly in the teeth, the ears being held shut to keep out other sounds. To determine the cause of the thump, the indicator was brought into play, and then it was discovered that this cylinder was doing no work, the oil being ejected into the exhaust pipe without being burned.

On shutting down the engine and taking out the exhaust valve, inspection showed distinctly that the piston head was wet with oil and that considerable carbon had

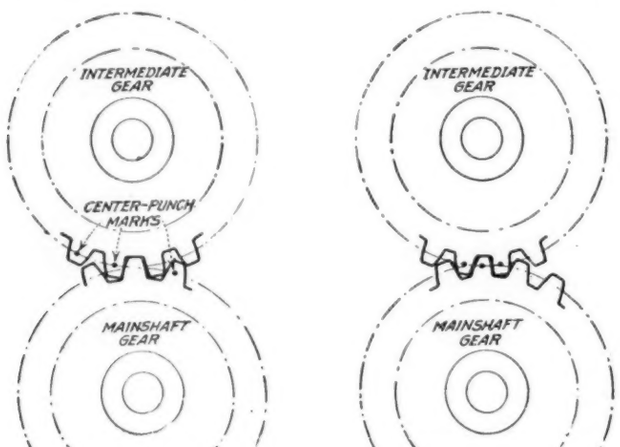


FIG. 1. SHOWING MISADJUSTMENT OF TIMING GEARS

formed on it. This carbon had caused thumping by striking the cylinder head at the end of the stroke. The indicator had shown a very low compression, so we dismantled the top gear, cylinder head, piston and connecting-rod and brought the piston down to the floor for better observation and repairs.

We found the upper two piston rings gummed solid in their grooves and broken in a number of pieces. The next four rings were carbonized badly, and only the lower wiping oil ring was in good condition. The cylinder walls were very gummy and dry, and all four openings for lubricants were filled with solid carbon and glazed over. There were some chewed-up spots near the upper part of the liner, caused no doubt by the sharp edges of the broken piston rings.

While assistants cleaned the piston and put shims under the piston-pin bearings, I fitted the new rings to the cylinder and passed them down to the men, who fitted them to the piston grooves by filing and scraping thoroughly. Next, we scraped, filed and smoothed

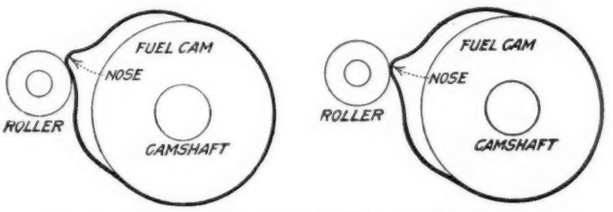


FIG. 2. INCORRECT AND CORRECT CAM SETTINGS

up the cylinder liner where it was rough, cleared the oil ways, and made sure, by testing each passageway, that the lubricant would reach the piston. All inlet and exhaust valves were ground in, after which all parts were re-assembled. While these jobs were being done, the engine was keyed up all around and given a thorough inspection.

When we started off, I noticed a slight wabbling of the flywheel, and on asking how long it had run that way I was told it had always done so. As all the bearings were in fine shape, none being low or worn to speak of, I ordered the engine stopped. Using a steel scale as a straight-edge on the planed surface of the hub, I found, as I had suspected, that the hub had not been placed absolutely true on the shaft. It was the work of only about an hour to loosen up the hub bolts, and, using an improvised ram made of a piece of 3-in. shafting swung from a rope, to true up the hub. After retightening the bolts and starting up, the wheel ran absolutely true. It is well to remember that a slight inequality in trueness of the hub will cause a wabbly wheel, which is an eyesore to a good mechanic.

The oil pump and the governor had been examined thoroughly, but on checking up the setting of the fuel cams and noses, something seemed amiss. The engine was barred over slowly, and when the valve timing was checked there was no further wonder why the engine had rebelled. The intermediate and main gears were out of adjustment by two teeth, as shown at the left in Fig. 1. This setting was corrected, as shown at the right in the same figure.

We next turned our attention to the fuel-cam noses. Fig. 2 shows at the left the setting as we found it before the intermediate gear was correctly adjusted, and at the right is shown the corrected setting. The engine was then started up and after putting on a full load it ran normally. The engineer declared that it ran better than he ever saw it do before. However, he had been on the job only about two months, as he had come from another Diesel plant in the East.

The indicator was applied to the engine and the diagrams showed normal action. So we switched the load back to the other engine and again put the repaired engine in parallel to make sure that everything was all

right before leaving. We waited for the peak load to come on, for we had sent out word to switch on the loads everywhere as the engines were all right again. The load came with a rush, but the engines stood up to it in fine style. As soon as the load dropped that night and one engine could carry it alone, we switched off all load from the repaired engine and applied the indicator. The compression pressures in all three cylinders were observed for future reference and were 480, 503 and 470 lb. per sq.in. in cylinders Nos. 1, 2 and 3, respectively. As No. 2 cylinder was the one that had been overhauled, the figures showed that the pistons of Nos. 1 and 3 should soon be fitted with new rings or else shims should be put in under the piston-pin brasses to increase the compression. This shimming can easily be done by the engineer. The piston can be jacked up and the shims inserted in the opening thus produced under the brasses.

Separation of Costs in a Combined Steam-Heating and Electric Plant

By H. W. MEYER

This article describes a method for separating the coal costs chargeable to the electric from that of the steam-heating department. All other boiler-room costs are divided between these departments in the same proportion as the coal costs.

WHEN exhaust steam from reciprocating engines or steam turbines driving electric generators is used for steam heating—both electric and steam-heating services being supplied to the public—it becomes necessary to separate the operating costs chargeable to each utility. This is necessary in order that equitable rates may be fixed for both classes of service and that the proper return may be earned on the investment for each. Such a separation of operating costs must be made on a basis that will bear scrutiny by rate commissions, by investigating committees or by the consumers themselves.

Other operating costs than those relating to the boiler room are either by their nature chargeable directly to one or to the other utility or they must be separated by some other means. For example, the maintenance of steam-distribution mains is purely a steam-heating charge, while general expense, including the salaries of general officers, office supplies and the like, applies to both the electric and the steam-heating departments. The separation of such costs as these might well be made in proportion to gross earnings.

Combination electric and steam-heating plants may operate under many conditions, and any method that may be used in the separation of costs must be sufficiently general in its application to cover them all. We may have a steam-heating load in excess of the supply of exhaust steam available, in which case live steam must be introduced into the mains in addition to the exhaust. If the reverse is true, the company should either secure additional steam-heating business or install condensers for some of its prime movers. In some cases both high- and low-pressure steam must be supplied, the former being used for cooking, laundry work and the like. The generating apparatus may be interconnected with other and more efficient steam-generating stations and with water powers. The generating apparatus may consist of reciprocating engine-driven or turbine-driven generators or both.

In arriving at the amount of coal chargeable to the electric department, we are justified in assuming that as much coal should be charged to this department as would be charged if similar generating units, operating under similar load conditions, exhausted into condensers.

It is assumed that the station contains a number of generating units and that only so many of these will be operated at any time as will permit each to carry approximately its most economical load. Under these conditions the steam consumption of each unit will be proportional to the kilowatt-hours generated by that unit. The number of tons of coal consumed for the generation of electricity will not be in proportion to the kilowatt-hours generated, but will depend on the output and the maximum load which the station must be in readiness to carry. We may say, therefore, that the total tons of coal consumed during an interval of time will be equal to a constant times the kilowatt-hours generated plus another constant times the maximum load that the station must be prepared to carry during such interval of time.

It must be remembered, in what follows, that all calculations are based on the performance of condensing generating units of the same capacities and kinds as those installed in the plant in question.

Since public utilities ordinarily make monthly operating reports, the logical unit of time in these calculations would be the month. Based on the foregoing statements, we may write the following equation:

$$\textit{Pounds of coal consumed per month} = K_1\ (\textit{kw.-hr.}) + K_2\ (\textit{kw.})$$

K_1 is equal to the pounds of coal per kilowatt-hour found by dividing the kilowatt-hours generated into the pounds of coal required when operating condensing after deducting an amount of coal equal to that which would be required to maintain a hot banked fire under the boilers required for generating electricity.

K_2 is equal to the pounds of coal per month required per kilowatt of maximum demand for which the station must be in readiness during such month, to maintain a hot banked fire under the boilers required for generating electricity; that is, fire just sufficient to maintain steam pressure without delivering steam.

K_1 may be found by the use of Fig. 1. For example, if the actual evaporation is found to be 6.5 lb. of steam per pound of coal and the banking fuel per developed boiler horsepower is 200 lb. per month, we follow the oblique line corresponding to 6.5 lb. to the intersection with the horizontal line corresponding to 200 lb. and follow the vertical line through this intersection to its intersection with the curve corresponding to the steam

rate (condensing) of the prime mover. The length of the ordinate at this point is K_1. If in this example we take the steam rate to be 17 lb. per kw.-hr., K_1 is 2.45 lb. of coal per kw.-hr.

K_2 may be determined from Fig. 2. Using the pounds of fuel required per boiler horsepower (developed, not rated boiler horsepower) for maintaining a live bank, as an abscissa, find the intersection of the corresponding ordinate with the line corresponding to the rated steam consumption (condensing) of the prime mover. The length of the ordinate at this place will be the value of K_2.

Fig. 3 may be used as an aid in determining the fuel required for banking when this is not definitely known and is based on data from actual operation. Fig. 3 refers only to rated boiler horsepower. Since boilers are often operated at 200 or 300 per cent. of their rating, over the peak, before applying to Fig. 2, these figures would be reduced proportionately.

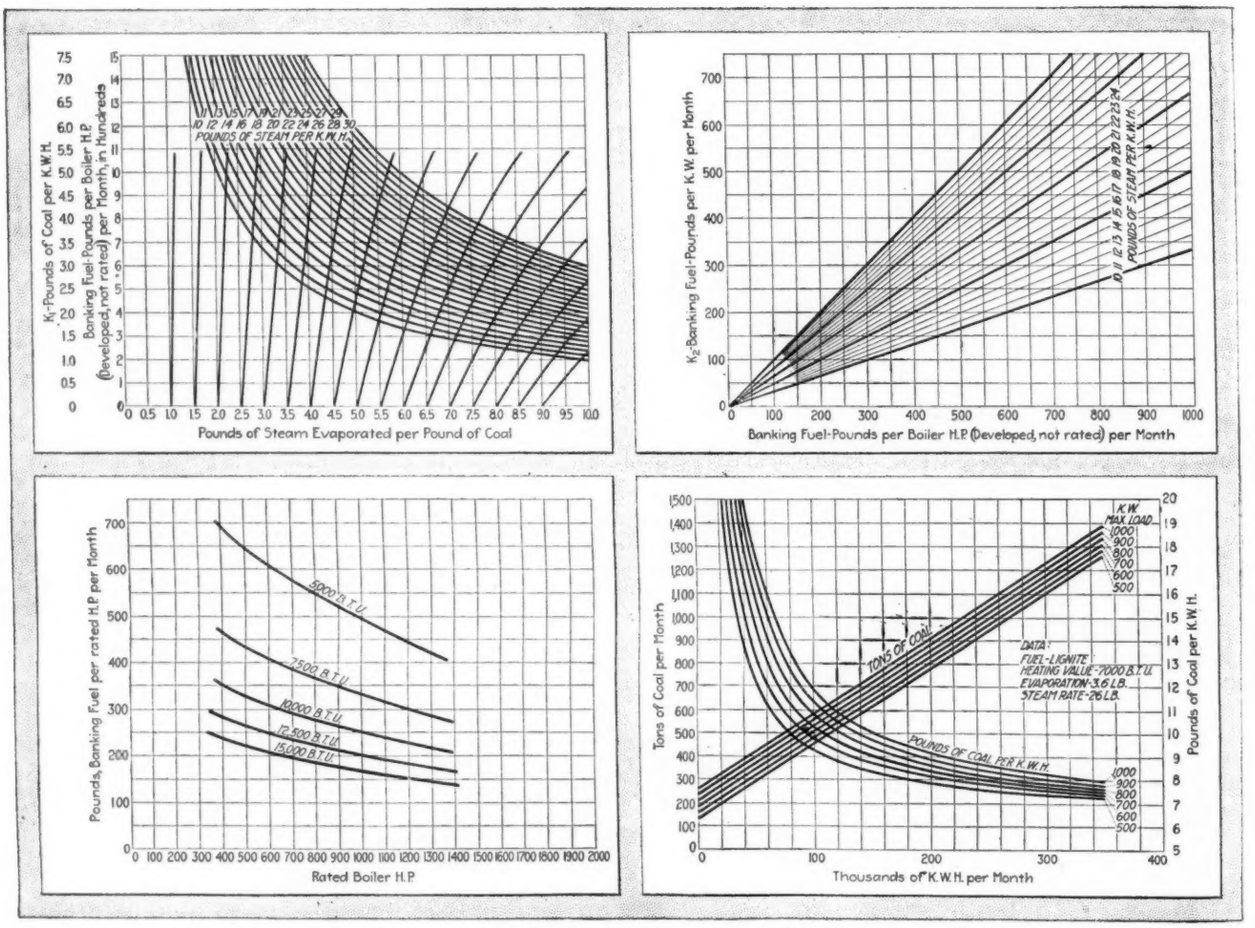
Fig. 3, of course, cannot be taken as accurate under all conditions, but is intended merely as a guide which may be of assistance in determining this factor where it is difficult to find it directly. In using it find the abscissa which corresponds to the horsepower rating of the individual boilers in question and then find the intersection of the corresponding ordinate with the curve corresponding to the heating value of the fuel used. The length of the ordinate at this place will be the pounds of banking fuel per rated horsepower per month (30 days). If the boiler is operated at 200 per cent rating, only one-half the amount found should be applied to Figs. 1 and 2.

Having determined the values of K_1 and K_2, they may be substituted in the equation,

Pounds of coal per month $= K_1$ *(kw.-hr.)* $\div K$ *(kw.)*

It will be found convenient to make up curves similar to Fig. 4 by the use of this equation.

When there is a wide difference in the steam rate of various units in a plant, it may be necessary to treat each unit separately.


K1-Pounds of Coal per K.W.H.
Banking Fuel-Pounds per Boiler H.P. (Developed, not rated) per Month, in Hundreds
POUNDS OF STEAM PER K.W.H.
Pounds of Steam Evaporated per Pound of Coal
K2-Banking Fuel-Pounds per K.W. per Month
Banking Fuel-Pounds per Boiler H.P (Developed, not rated) per Month
Pounds, Banking Fuel per rated H.P per Month
5000 B.T.U.
7500 B.T.U.
10000 B.T.U.
12,500 B.T.U.
15000 B.T.U.
Rated Boiler H.P
Tons of Coal per Month
K.W. MAX. LOAD
TONS OF COAL
DATA:
FUEL-LIGNITE
HEATING VALUE-7000 B.T.U.
EVAPORATION-3.6 LB.
STEAM RATE-26 LB.
POUNDS OF COAL PER K.W.H.
Pounds of Coal per K.W.H.
Thousands of K.W.H. per Month

FIGS. 1 TO 4. CHARTS SHOWING THE SEPARATION OF COSTS IN A COMBINED STEAM-HEATING AND ELECTRIC PLANT

Fig. 1 (upper left)—To find the number of pounds of coal per kilowatt-hour. Fig. 2 (upper right)—For finding the number of pounds of banking fuel per kilowatt-hour per month. Fig. 3 (lower left)—To find the number of pounds of banking fuel per rated horsepower per month. Fig. 4 (lower right)—For finding the number of pounds of coal used per month.

The following form is suggested as a means of keeping a record of these data:

Name of Company..... Plant.....

Month.....

Determination of Fuel Chargeable to the Generation of Electricity

Unit No.	Capacity, Kw.	Kw.-Hr. Generated	K_1 K_2	Pounds of Coal = K_1 (kw.-hr.) ÷ K_2 (kw.)
1				
2				
3				
Totals,				

Calculated by.....

EDITORIALS

To Earn More Learn More

SOME forty years ago a number of power-plant engineers got into the habit of meeting in the engine room of the court house at Providence, R. I., and talking over the problems of steam engineering. At first irregular and informal, these gatherings developed into an organization which, uniting with and inspiring similar organizations in other cities, led to the founding of the National Association of Stationary Engineers, an organization unique in character, evolved naturally out of the environment in which the craft found itself.

The steam engine, the mainspring of the factory system, the muscle of industry, had come into its own. The steam plant, simple as it then was compared with the plant of today, had an interesting technology, offered opportunities for all sorts of savings through the exercise of invention, intelligent supervision, and ingenious application. The indicator was becoming known to the operating engineer, valve setting was becoming less of a shop mystery, there were different methods of firing to discuss, and various methods for making the operation of the steam plant more dependable and economical to be devised and considered.

One may realize the possibilities of those times by looking over the advertising pages of the current issue of *Power* and noticing how many of the devices there presented have been produced and have made fortunes for their inventors and promoters in the intervening years.

The men in charge of those plants were not technically trained men, that is from the technical-school point of view. Even the technical schools had looked askance upon the engine at first as a subject of scientific teaching and it was only at about the time of the inception of this association that steam laboratories began to be considered as legitimate features of the equipment of such institutions.

These practical men, drawn together by a common interest in their vocation, obliged to work out its theory and principles, to learn its traditions and fundamentals by their own effort and from sources which they must aid each other in seeking out, perfected an organization based upon mutual helpfulness in learning, which has endured for thirty-seven years and the delegates to whose annual convention at Huntington, W. Va., this week represent some twenty thousand members scattered all over the country. They looked for progress and uplift for the individual and for the craft through education. Their motto is "To Earn More Learn More." They considered themselves as in rather the executive than the operative class, as heads of departments rather than as "hands," and expected to better their condition rather by improving their capacity for service and their capability for assuming responsibility than by the exercise of the collective demand.

This is a spirit which should have been welcomed and cultivated by every owner or manager of a steam plant. It can safely be said that without the opportunities for study and training afforded by this and similar organizations which have sprung up it would have been much more difficult to provide that combination of practical and theoretical man that is necessary to the most successful operation of the complicated modern plant. Many of the members of the association have won recognition and fill positions of responsibility and emolument, but the recognition has been far from universal.

It is probably natural that employers should have responded more readily to organized demand than to modest nonassertiveness, awaiting spontaneous recognition of its increased worth. But it is regrettable that employers should have allowed a situation to develop where the organized mechanic or mason can boast to the chief engineer who employs him that he works fewer hours for higher wages than the engineer does. A cordial recognition of the engineer in the spirit of this organization might even now be a wise precautionary measure as well as an act of justice to a more than ordinarily deserving and a less than ordinarily appreciated class.

Refinements in Steam Turbine Design

THE growth of the steam electric power industry has reached the stage where the users are evidencing keen interest in the practices and problems of the designers. This is an important step in the progress of the art in that it will bring about a closer engineering analysis of designs submitted by manufacturers, and will be an important factor in stimulating development along lines in which proper relative consideration will be given to reliability, efficiency and cost.

In this connection, the article entitled "Refinements in Steam Turbine Design" by Prof. A. G. Christie, will be read with much satisfaction, particularly by users of steam turbines.

The problems referred to in this article have been familiar to designers for years, and much has been done toward their solution. The early success of the turbines introduced by the Honorable Charles A. Parsons was largely due to the progress he made in the solution of the problems of detail design. Further slight gains along these lines are still possible and closer attention will be centered on them as sizes and general designs become further standardized so as to require less attention on the part of designers, and as costs of fuel, with corresponding demand for greater refinement in efficiency increases.

That the ultimate turbine will employ high blade speeds and high stresses is debatable. Higher efficiency and greater durability of the blade or bucket elements are to be obtained by keeping the velocities as low as practicable. Polished surfaces cannot be maintained, especially in machines which are not in continuous operation and therefore subject to corrosion, nor in machines which employ extremely high speeds where

erosion is active. With low speeds, both erosion and friction losses, which polish tends to reduce, are minimized.

While the highest obtainable efficiency of a machine when new is of some importance to users, the actual average operating efficiency over a term of years comprising the useful life of the machine is of considerably greater importance.

All turbine elements are designed along lines believed to be theoretically correct. Increasing experience affords more accurate knowledge of the relative importance of the various factors involved and thereby leads to further improvement.

Rising costs of fuel and labor and the resistance against corresponding increase in power rates are factors which are forcing both the designer and user to exert every possible effort toward obtaining the highest possible efficiency in design, manufacture, and operation of our present-day electric power apparatus.

Increasing Application of Alternating-Current Machinery

THE tendency in the application of electricity to light and power purposes is toward a greater use of alternating current. There is one field, however, where direct-current must be used; namely, in electrolytic work, and, at the present stage of development, is also preferable in electric welding. Where adjustable speed motors are required for wide ranges of speed the alternating-current machine has not as yet reached a development so as to successfully meet these requirements. However, when the need for such an alternating-current motor becomes sufficiently urgent there is little doubt that such a machine will be forthcoming. In fact such machines have already been developed but have not up to the present become a serious competitor of the direct-current machine. Outside of these applications alternating-current equipment compares favorably with direct-current machinery and in some cases is superior.

There seems to be a tendency on the part of practical electrical men to look upon alternating-current equipment as something mysterious. Not infrequently the statement is made "I understand direct current but alternating current, that is so complicated I never could understand it," when the chief reason for the lack of understanding is absence of study of the subject. If one has become familiar with direct-current machines through five or ten years' association with and study of this equipment, it is not reasonable to expect to have the same understanding of alternating-current equipment by only a casual consideration of the subject, and this with the idea fixed in the mind that the subject is very complicated. The true facts of the matter are, one is no more complicated than the other, in fact most alternating-current motors are more simple than direct-current machines, and the alternating-current motor of the induction type operates on the same principle as the direct-current machine, the only difference being in how the current is obtained in the rotating element's conductors. To assist in clearing away some of the mystery with which some of our readers have shrouded the operation of an induction motor, there is published on page 382 of this issue an article "The Rotating Magnetic Field of Alternating-Current Motors" which shows that the revolving magnetic field is produced in practically the same way as taking two permanent bar magnets and arranging them in consecutive positions on a plane so that they move across the surface in steps equal to the width of one magnet. A conscientious study of the explanation given in this article should prove a basis of a more intimate acquaintance with the principle of alternating-current motors.

The Biggest Move Since the Preamble Was Written

THE National Association of Stationary Engineers is the largest and perhaps the only body of its kind in the world. For the nearly twoscore years of its existence it has held apart from labor interference, spurned numerous attempts to convert it to a labor union, yet without suggesting that individually its members should not affiliate with such organizations.

According to its preamble it is avowedly an educational institution. It seeks to better the working and living conditions of its members through higher knowledge and greater skill in power-plant operation. However, the engineers of late have taken comparatively little interest in educational programs. Take, for example, the number of members entering the contest for the prizes offered by the National Educational Committee of the National Association of Stationary Engineers. It is most disappointingly low. And, be it understood, not because the committee's plan was not good—it was exceptionally meritorious. But the men were not interested. It is one thing to be interested, but another to be sufficiently interested to be stimulated to do that in which you are interested. There is not one in all the more than twenty thousand of this association who have been charged with the responsibility of the national or subordinate association educational work who does not know how exceedingly difficult it is to keep the men actively engaged in the educational affairs.

There are two causes: One, that many of the men, like so many others in this field, have lost heart, because of the meager reward for the effort; the other, that members, growing old and naturally less interested than youthful ones, dominate affairs—business, educational and social. There is not enough young blood.

The appointment of a technical papers committee at a recent convention and the setting apart of time for welfare discussion by the delegates to the national convention was a great forward step. It marked the beginning of a new era for the association. This year, at the coming convention, will be taken a step which in fruitful possibilities will be greater still, will in fact be the biggest step taken since the adoption of the preamble. The resolution aims to permit the association to take in as members engineers who are eighteen years of age, instead of holding up the limit to twenty-one as at present. Some states permit a man of eighteen to hold a license. The fact is that today men are reaching a given stage in industry and human affairs at an earlier age than was common years ago. Here is the source of that fertile young blood so much needed.

And now the International Union of Steam and Operating Engineers, affiliated with the American Federation of Labor, is formulating a plan to strike for eight dollars for an eight-hour day and double pay for overtime. The engineers of a single industry are not numerous and could be easily replaced, but it would be difficult to conceive of anything which would tie a community up more than shutting down its steam plants.

Correspondence

Surface Condensing Plant Temperatures

In *Power* for July 15, page 92, there is a short article entitled "Surface Condensing Plant Temperatures," which gives information that appears erroneous and misleading. Good surface condenser practice at present does not require 10 deg. F. difference between hotwell temperature and theoretical vacuum temperature and it does not require 15 deg. F. to 30 deg. F. between hotwell temperature and cooling-water discharge temperature. Fortunately, in the preceding article describing a recent condenser installation you have provided me with data necessary to prove my point. From data available I have made the following tabulation:

	Recommended Practice in Article in Question, Deg. F.	Worthington Condenser Guarantee, Deg. F.
Circulating water, inlet	70	70
Rise in temperature of circulating water, assuming 920 B.t.u. per lb. steam and 78 to 1 water-steam ratio	12	12
Circulating-water outlet temperature	82	82
Difference circ.-water and hotwell temperature	15 to 30	11.8
Difference hotwell temperature and vacuum temp.	10	
Vacuum temperature	107 to 122	93.8
Vacuum, 30 in. bar, in. mercury	27.6 to 26.4	28.4

Clifton, Ariz. N. G. HARDY.

Flue-Gas Analysis and CO_2 Recorders

Mr. Baxter's article on "Flue-gas Analysis and CO_2 Recorders," in the issue of July 22, certainly throws light on a phase of boiler economy that is too often disregarded. If it is desired to obtain a record of the oxygen in the flue gases, and the size of the plant justifies the added expense, it can be done by the use of two recorders, as shown in Fig. 1.

The CO_2 recorder would operate as usual, with a solution of KOH (potassium hydroxide), while the oxygen recorder would operate with pyrogallos and KOH, like the Orsat. The CO_2 would be removed from the gas going to the oxygen machine by a solution of caustic soda in the scrubber tank between the two machines. This tank should hold about three gallons, containing, say, 15 lb. of soda, which would give purification for two or three months, on 24-hour operation,

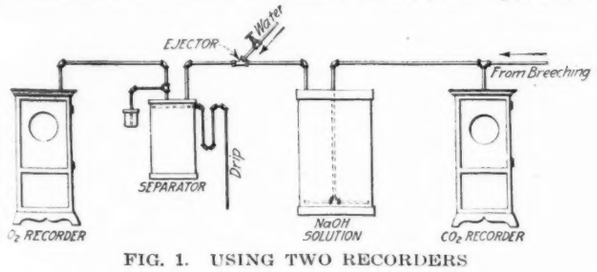


FIG. 1. USING TWO RECORDERS

assuming that one-half the gas purified was used in the recorder.

Owing to the increase in volume of the solution as it changes to carbonate, a small space should be left for expansion.

An ejector made up of small pipefittings and operating on water pressure would draw the gas through the soda solution, the water being taken out in the separating tank, and a small water-sealed vent provided to prevent undue pressure, which might affect the accuracy of the recorder. A small amount of gas discharged through the water seal would do no harm, except to use up the soda, and would materially decrease the time lag of both machines. The actual percentage of oxygen in the gas would be $\frac{100 - CO_2}{100} \times O$ This would give an accurate record of excess air, affected only by the oxygen burned to water due to the hydrocarbons in the coal.

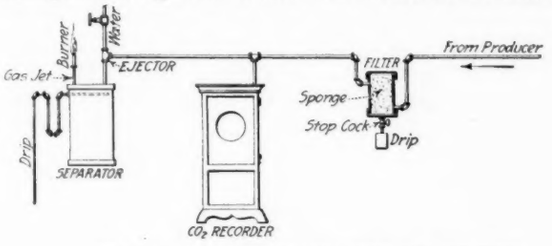


FIG. 2. ILLUSTRATING USE OF FILTER

We have been operating a recorder for the last year on anthracite producer gas and find it essential to accurate operation that the gas be thoroughly clean. By means of the connection shown in Fig. 2 we not only clean the gas, but materially decrease the lag of the recorder. The water valve is regulated to keep a $\frac{3}{4}$-in. burner going nicely; this arrangement gives a lag of less than 5 min., about the interval between successive records.

We are obtaining gas averaging less than 5 per cent. CO_2 for a 24-hour run, on continuous operation, and have, under favorable conditions, obtained gas showing less than 3 per cent. for an entire 24-hour period. This was with a new fire, in a 7-ft. producer, making approximately 15,000 cub. ft. of gas per hour. Can you beat it? A. H. BULLARD.

Syracuse, N. Y.

Pressure on Crankpin and Guide

The solution of pressure on crankpin and guide, page 29 of the July 1 issue, appears to be in error. Where CB is the length of connecting rod and CA is the distance from center of crosshead pin to center of shaft, or horizontal distance from the crosshead pin to center of crankpin, when the crank is at right angles to the direction of stroke, then the thrust on the connecting-rod would be $CB \div CA \times$ pressure on the piston, or $5 \div 4.899 \times 9000 = 9185$ lb., in place of 8818.2 lb., and the pressure on the guide would be $\frac{1}{4.899} \times 9000 =$ 1837 lb., in place of 1763.6 lb. A. VENNING.

Brooklyn, N. Y.

[The correspondent is right and the solution given is in error, as he has pointed out.—Editor.]

Why Not Express Vacuum Values in per Cent?

After having traveled from Denver, Colo., to New Haven, Conn., it would seem to me that it would be so much more satisfactory if vacuum values were stated in per cent. instead of in inches by engineers. It is lamentable to find so many engineers and chief executives under the impression that they should be getting 28 in. of vacuum at altitudes of 1000 to 1500 ft. above sea level.

Some years ago, while operating a plant that was located about 1200 ft. above sea level, I turned my hair gray trying to maintain 27 in. of vacuum in everyday practice on a low-level jet condenser with water coming from a cooling pond. After I had studied night and day and tried everything I could think of, as well as the various suggestions and recommendations of several condenser experts from the manufacturers, I was still in the dark.

About this time I made a trip east to a convention, and while there I secured all the data I could on vacuum, condensers and cooling ponds. This experience caused me to think of the idea of expressing the vacuum in per cent., since the barometer was different in almost every case. Furthermore, I observed that the actual barometer varies considerably below that which corresponds to the local altitude, as the relative humidity has a greater effect than most persons realize.

VACUUM EXPRESSED IN PER CENT.
Average Values in Everyday Operation

Locality	Weather	Barometer, Inches Hg.	Vacuum Inches, Hg.	Vacuum Per Cent.
New Haven, Conn.	Fair	30	28	93.4
	Stormy	29.6	27.6	93.5
		Maximum	Maximum	
Dayton, Ohio.	Clear	30.4	29.4	96.5
	Fair	29.3	27.4	93.5
	Stormy	28.9	27.4	95
		Maximum	Maximum	
Akron, Ohio.	Clear	29.7	28.6	96.5
	Fair	29.1	27.2	93.5
	Stormy	28.7	26.8	93.5
		Maximum	Maximum	
Kansas City, Mo.	Clear	29.4	27.4	93.0
	Fair	28.7	26.8	93.5
	Stormy	28.3	26.4	93.5
	Clear	29.1	27.2	93.5

Note—Lowest barometer occurs before a thunderstorm or during a snowstorm.

At the present time the vacuum in inches means nothing to me until I know the actual barometer; then I divide the vacuum by the barometer in inches, which gives the value in per cent.

As a 28-in. vacuum with a 30-in. barometer at sea level on the Atlantic coast is considered a good everyday average, I use this as a basis for comparison. Dividing 28 by 30 we get 93.33, or nearly 93.5 per cent. vacuum.

Perhaps some engineers will say this is too low, that they maintain 28.7 in. vacuum or 95.6 per cent. every day. So have I. However, I have never been able to observe any decrease in the readings of the steam-flow meters (including auxiliaries) after increasing the vacuum to this value. I have found this to be true on all three of the leading makes of turbines up to 10,000 kw. capacity. I think this is easily accounted for, as a turbine designer has just recently admitted that very few turbines are able to secure the full benefit of this increased vacuum because the last row of blading cannot be commercially built to handle this enormous volume of steam.

In this connection I might mention that I have observed three instances in which the flow meters did not show an increased flow when the vacuum was dropped 3, 5 and 7 per cent. respectively (steam flow to turbine only). This was due to leakage in the dummies and boiler smudge in the blading. The flow meters were carefully calibrated and all piping tight.

The accompanying table shows actual conditions as observed by myself with values expressed in per cent.

Franklin, Ohio. WALDO WEAVER.

Danger of Oil in Boilers

A certain tannery uses its five horizontal-return-tubular boilers to operate noncondensing engines and some live steam to supplement the exhaust for heating and drying purposes. All the exhaust steam is condensed in banks of heating coils, the drips returning to an open heater, from which the condensate is fed to the boilers.

The oil separator on the side of the feed-water heater was imperfectly dripped and permitted oil to go to the heater. Although the well-placed oil separators in the exhaust lines near the banks of heating coils were of excellent design, they were improperly dripped. It is well known that the drain from an oil separator should be continuously free and open. No valves are needed in such drains, and their presence is a menace as, if carelessly or ignorantly shut, the separators cease to operate and oil passes into the coils. It is usually necessary to provide a pipe seal for the drain from the oil separator in order to adapt it to the exhaust pressure.

These drains in the tannery were equipped with valves, and one separator had its drain hooked up to a system of pipes discharging at an elevation of about five feet above the separator, these pipes being used for other purposes. This resulted in a checking of the drain from the separator, a defect which had existed for three years.

Boiler-insurance inspections, about a year ago, had called attention to the presence of oil in the boilers. The first warning of injury came with leaks around the girth seam of the shell immediately over the fire. This was followed by the rear tube ends leaking. Calking and reëxpanding stopped the leaks for a time, but they reappeared in aggravated form, until it was evident that the situation was serious if not dangerous. An examination disclosed considerable oil in the boilers, and the defects in the oil-separator drains were found.

Measurements showed that the boiler shells had been bowed-up, or "hogged," the permanent arching being five-eighths of an inch in the shell length of 16 ft. The lower tubes had been pushed through the back tube sheet a distance of one-quarter of an inch, although they were not only expanded but the ends were beaded. The 1½-in. braces joining the heads below the tubes were bowed up about three inches and touched the tubes. The lower tubes were bowed up about an inch.

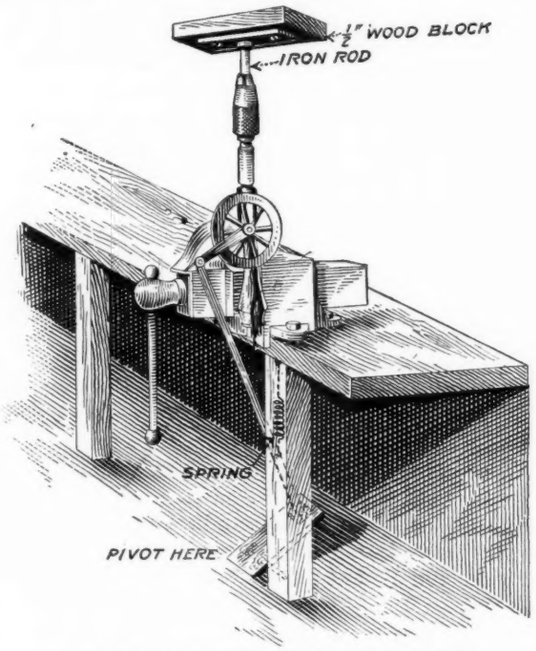
How did the boilers happen to bow upward? If a bar of iron is heated and cooled repeatedly, its length is reduced. The oil on the lower sheets of the boilers was an excellent nonconductor of heat and checked the flow of heat to the water, thus causing the shell to become overheated to some extent. This repeated overheating of the bottom of the shells drew the lower edges of the heads togther by the shortening of the length of the bottom of the shells, the top of the boiler remaining undeformed, the tubes being pushed through the rear head. JAY M. WHITHAM.

Philadelphia, Penn.

Cleaning Boiler-Tube Plates

Cleaning the tube plates of a boiler is a tedious operation. In a certain plant the plates were washed and allowed to dry, and the ground surface was then cleaned by rubbing the plate on a smooth board on which fine crushed ashes were spread.

This work was afterward facilitated by means of the simple device shown in the illustration. A common breast drill was clamped in a vise and a pedal attachment arranged to revolve the handle. A circular piece



DEVICE FOR SURFACING TUBE PLATES

of smooth board, one-half inch thick, was attached to a piece of quarter-inch iron. This was then clamped in the chuck of the breast drill. As the board revolved ashes were thrown on the board and by pressing the cap against the revolving surface the plate was rapidly cleaned.

Fine emery cloth may be used instead of ashes.

Richmond, Va. JAMES M. PURCELL.

Boiler Blowdown Indicator

The illustrations depict a device that I have designed, the purpose of which is to show when the boilers have been blown down.

Two bands are secured to the blowoff pipe with two iron rods clamped between, as shown in Fig. 1. Double points on the rod *A* are not necessary, but care must be used to get the contact points so that they will meet when the pipe expands. The bent part of the rods should be thin enough to give if the expansion exceeds that for which the rods are set, usually about $\frac{1}{16}$ in. The contacts are insulated as at *C*. If a watchman's electrically operated time-recording clock is used, wires from the rods are connected to the clock. As connection may be made for some time, it will be necessary to sharpen the edge of the clock punching pin so that it will cut the disk instead of crumpling and tearing it due to the disk movement. The slit in the disk will show the time and duration of the blown-down period.

If no watchman's time clock is available, an outfit such as shown in Fig. 2 can be made. It consists of a piece of 2-in. iron pipe open at the top and capped on the bottom. *B* is a ¾-in. globe valve with a threadless valve stem. The rod *D* is connected to the blowoff pipe as shown in Fig. 1 and has movable joints at *C*, *E*

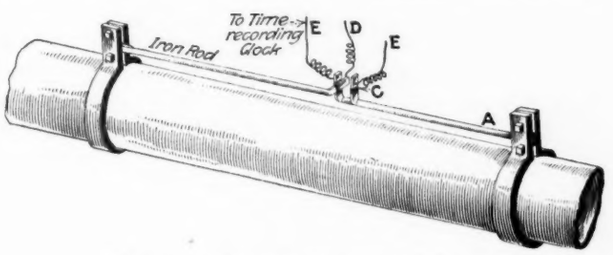


FIG. 1. CONTACTS ON BLOWOFF PIPE

and *F*. The rod *D* is moved by expansion of the blowoff pipe in the direction of the arrow. A water-glass *H* is attached to the iron pipe which also contains water.

When the boiler is blown down, the expansion of the pipe will in the case of the watchman's clock move the rods sufficiently to take an electrical connection at *D* and *E*, and in the second case open the valve *B*, Fig. 2. By experiment the gage can be marked on the pipe or on the glass with paint for minutes, half or quarter minutes, or for inches of water blown down.

The circuit will open in a very short time after the

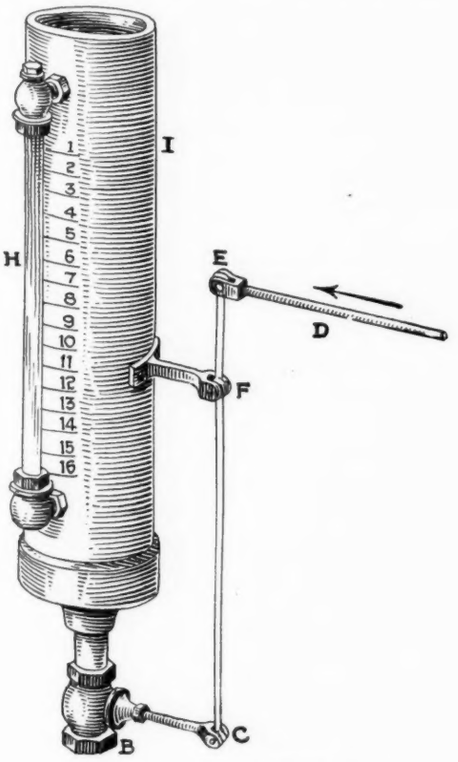


FIG. 2. BLOWDOWN GAGE

blowoff cock is closed, as the temperature drops very fast for the first 100 degrees.

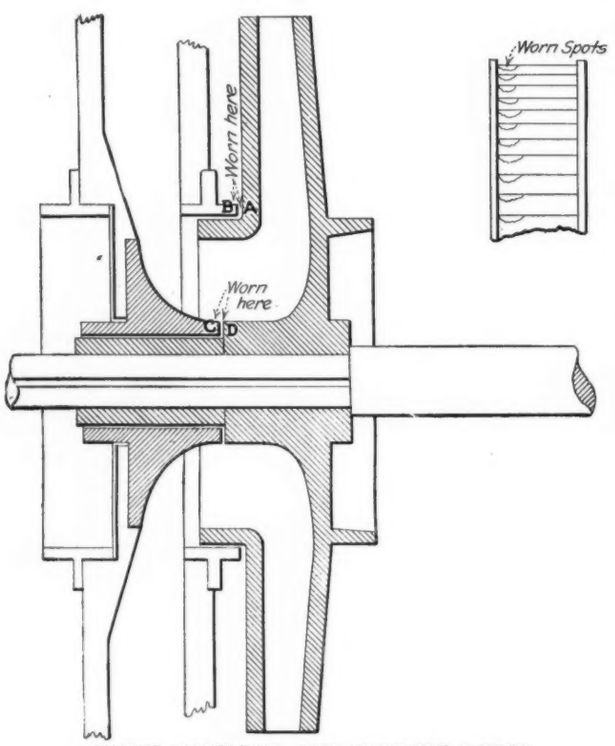
The recorder has another good point—if the blowoff cock leaks enough to heat the pipe or if it should be left slightly open due to scale getting under the valve disk, it will show up the leak. JAMES E. NOBLE.

Kingston, Ont., Canada.

Repairing a Turbine-Driven Centrifugal Pump

The following account of trouble with a centrifugal pump and a description of the method of repair may be of interest to readers of *Power*. The pump is a four-stage centrifugal used for boiler feeding and for operating a turbine cleaner for boring boiler tubes at such times as it is necessary. The speed is 2100 r.p.m. and the pump was built to deliver about 200 gal. per minute at a pressure of 200 lb. It had operated satisfactorily until about two months ago, when a marked falling off in capacity was observed and it was decided to give it a thorough overhauling as no one had any recollection of its being opened up since its installation several years ago.

This statement will be less wondered at when it is explained that the pump was not built with a split casing and required the breaking of the suction line, the removal of the end casting of the casing and the removal of three castings per stage which formed the suction ring and diffusion vanes for each stage, as well as the removal of the rotors from the shaft as fast as each separate stage was reached.



WORN IMPELLER AND TURBINE ROTOR

The thrust bearing was at the extreme end of the shaft at the suction end, and when it was removed the cause of the trouble was apparent, as the bearing had at some time run hot, which had softened the metal and allowed it to yield to the pressure exerted by the thrust, thus permitting the whole rotating element to pull endwise about one-quarter inch, which had the effect of reducing the discharge opening from each stage about one-half, thus accounting for the reduction in capacity.

When the end casting was removed, our real troubles began. The castings comprising the suction ring and diffusion vanes are about 30 in. in diameter and are a tight fit inside the pump casing, necessitating the use of six ¾-in. pulling rods on each disk and the heating of the outside of the casing, the latter being accomplished with the aid of a perforated section of an old steam hose which was tightly lashed to the casing, liberally covered with old burlap and connected to a steam line. After the pump was thoroughly heated, the pulling rods were taken up tight enough to remove the disks.

When the disks and pump rotors were all removed, it was discovered that the impellers were badly worn on the suction side, as shown in the illustration at *A*, *B*, *C* and *D*, which also shows the wear on the renewable sealing rings and suction ring, this wear being caused by the rotating parts pulling endwise when the thrust bearing let go. The impellers did not show any wear due to erosion, so it was decided to repair them in our own shop by filling in the worn places with bronze.

By reference to a cut of the pump and measurements taken from the diaphragms the total end clearance was determined to be $\frac{7}{64}$ in., and the impellers and sealing rings were finished to give that clearance. A new shaft was made to the same dimensions as the old one, and as it was thought best to try the pump for end clearance before assembling it in place, it was assembled on the shop floor and the end clearance was found to be ⅛ in. The parts were assembled in the casing, all the connections made, and the shaft was then pushed as far as it would go toward the discharge end and the shaft marked in line with the end of the outboard bearing nearest the thrust bearing. Then it was pushed as far as it would go toward the suction end and the shaft marked at the end of the same bearing. The distance between these two marks was a measure of the end clearance, and it was found to be the same as when assembled on the shop floor. The clearance was then split and a new mark made on the shaft one-half the distance between the other two and the shaft pushed toward the discharge end until the new mark was even with the end of the bearing. A new thrust bearing was then put in place and shims placed between it and the end of the outboard bearing to bring the center mark in line with the end of the bearing.

When the pump was started we had no trouble in bringing it to its rated capacity; the expense was about one-third the cost of new running parts. The filling in of the impellers was done with an oxyacetylene-welding outfit. Another job done at the same time to the blading of the turbine that drives the pump may also prove of interest. It consisted of welding Tobin-bronze sections onto the blades at the point where the steam strikes the blade which had become worn by the action of wet steam (see insert illustration).

The worn places were about ¼ in. deep and ⅜ in. long and were filled in and then dressed down by hand to conform to the shape of the blade.

Only one or two blades in a place were done at a time, the wheel being turned to a new position to avoid undue heating and consequent warping of the wheel.

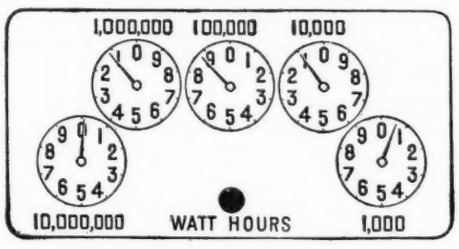
After the job was completed, the wheel and shaft were placed on balancing ways, but the wheel balanced so well that nothing was done to it to improve the balance.

This is the first repair of this kind of which I know, and if it proves to be a permanent job it will mean a saving of about $60 over cost of new blading and a saving of $80 over the cost of a new wheel. The set runs at 2100 r.p.m. without vibration.

Holyoke, Mass. C. B. HUDSON.

What Does the Meter Read?

The reading of watt-hour meters is something that is of interest to about everyone, no matter what may be his position, and the interest to operating engineers and electricians was shown in the June 17 issue of *Power* by the large number of answers submitted to the problem, "What Does the Meter Read?" To keep up



WATT-HOUR METER DIALS

the interest and give the readers of your publication another chance to test their ability to correctly read a tricky arrangement of watt-hour meter dials, I am submitting the problem shown in the figure. This is one that showed me that I needed a little more experience in meter reading before I could be sure of reading them correctly in every case. A. A. FREDERICKS.

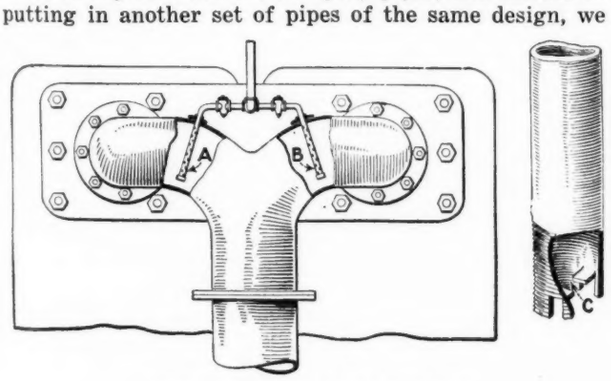
Chicago, Ill.

Exhaust-Pipe Spray Pipes Clogged

The illustration shows an exhaust pipe on a blast-furnace gas engine in which trouble was had with the sprays *A* and *B* clogging with mud and scale, and created a good deal of inconvenience.

The exhaust pipes are 26 in. in diameter, and a 1-in. pipe extends down into the exhaust, from the top, to a depth of 20 in. as shown at *A* and *B*. Each pipe contained thirty-six ¼-in. holes, the inner ends being plugged. This gave the desired spray effect as long as the small holes were free from mud, but after being in use awhile it was necessary to shut down in order to clean out the sprays.

We finally removed the old spray pipes, and instead of putting in another set of pipes of the same design, we



OLD AND NEW SPRAY PIPES

upset the internal edge of a 1-in. pipe, as shown at *C*, where it enters the flange on top of the exhaust pipe. No originality is claimed, but we thought it might help some unlucky engineer who is fighting hot exhaust manifolds on large gas engines. To get the best results with the pipe cut as at *C*, cut about 1½ in. of threads on the pipe, and with a hacksaw cut two slots in the end of the pipe, ½ in. deep and ¼ in. apart, and bend the two narrow strips in toward the center.

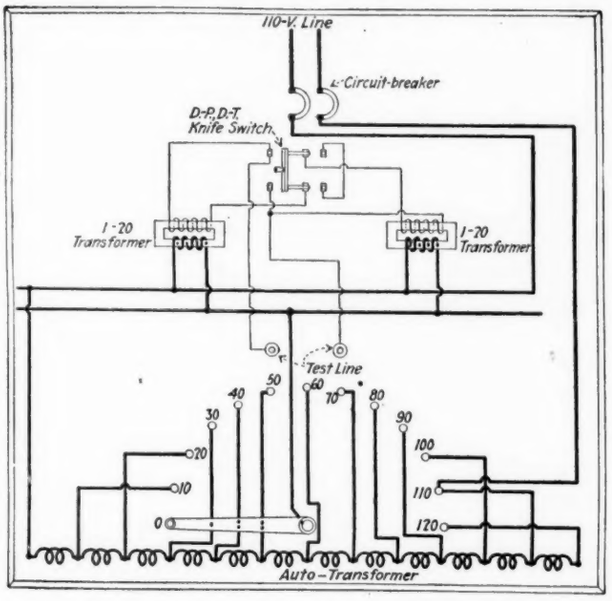
The pressure of the exhaust discharge, together with the split stream of water striking the exhaust at right angles, will make sufficient spray to keep the exhaust pipes cool. A. L. FRITZ.

South Chicago, Ill.

Insulation-Testing Panel

It is almost a necessity around an electric shop to have some convenient means of applying voltages of two or three times the working voltages to motors, transformers, etc., that are being repaired. I have in my shop such a test panel made from materials that can be found easily and it fills the need nicely.

A discarded switchboard panel was utilized, on which was mounted the equipment, consisting of a circuit-breaker, a double-pole double-throw knife switch, two standard instrument potential transformers, a sign-lighting transformer with 13 taps, a dial switch, and two receptacles for the insertion of the high-potential test lines. The arrangement can easily be followed



WIRING DIAGRAM OF TESTING PANEL

from the figure. At the top is mounted the circuit-breaker through which the 110-volt alternating-current line feeds; then the switch, which, when thrown to the left puts the transformers 2000-volt windings in parallel, and to the right in series. Since the sign-lighting transformer is really an auto-transformer, the voltage applied to the low side of the potential transformers is easily varied by means of the dial switch, and thus by manipulating the knife and dial switches any voltage from 0 to 2400 may be obtained in 200-volt steps, or by throwing the knife switch to the right any voltage from 0 to 4800 may be obtained in 400-volt steps. The circuit-breaker is set to trip on a failure of the insulation under test.

This outfit works very well on apparatus that is not too large. On large equipment that might have considerable electrostatic capacity, it would of course be too small, but for the average shop it is all right.

J. M. WAUCHOPE,
Chief Electrician
International Smelting Co.

Tooele, Utah.

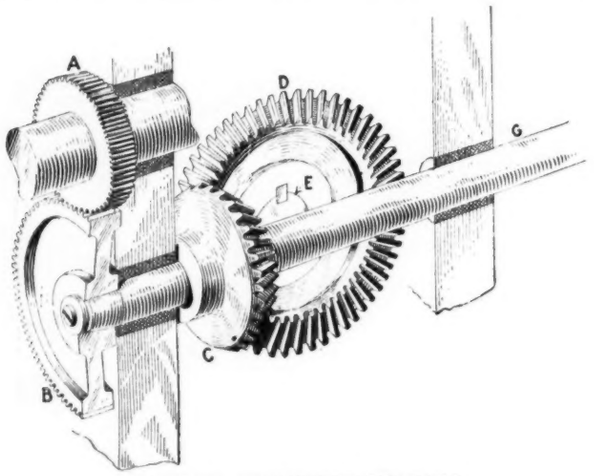
Some Gas-Engine Troubles

At one time I had charge of a plant consisting of four large gas-engine units—one three years old and in comparatively good condition, and the others about eight years old and in bad shape.

Three of the units were required to carry the load, and by keeping the new engine on all the time and switching out one of the old ones that happened to be in the worst shape, we had begun to improve the conditions of the old one and were hoping to have it easier.

The new unit was known as the No. 4 and the old units, Nos. 2, 3 and 1 respectively. The outside of both cylinders being badly cracked, we had just got No. 3 in pretty good shape mechanically and had it on the board with the other three units for a tryout, when without warning, the 2 to 1 gears on No. 4 crashed out through the gear case and the flywheel kicked the pieces promiscuously around the power house.

We had a heart-breaking time trying to keep the power on with the three old units until we could get new gears for the good engine. A set of gears had



LAYOUT OF ENGINE GEARING

never been broken in the history of the plant, and a pair was not carried in stock, so we had to order from the engine builders. A pair was also ordered made at a local shop. Both sets came at about the same time, and as one of the engine builders' gears was a little bit faulty, one of the locally made gears was put on with one of the builders' gears, and the good unit put back in service.

The cracked cylinders were leaking so badly on No. 3 by this time that we had to cut it out of service as soon as we could tinker up the other two old units so that they looked halfway safe, and put on a new pair of cylinders.

This was a long job, and before we could finish it, we lost another set of gears on the good engine. We worked all night to get the faulty gear supplied by the engine company and the other machine-shop gear on in time for the Fourth of July load. It ran for about twenty-four hours and broke up this set, but we hurriedly finished the No. 3 job and got it back under load.

The construction of the reducing mechanism on the engine was as shown in the accompanying sketch. The main shaft was 18 in. in diameter and carried the spur gear *A*, which meshed with the spur gear *B* on what was known as the cross-shaft *G*. The cross-shaft carried a bevel pinion *C* which meshed with a bevel gear *D* on the camshaft *E*. A thrust washer between the engine frame and the pinion *C* held it in mesh with the gear *D*. The spur gear *B* was bored on a taper and pressed on the shaft and keyed with a screw. When putting on the last set of gears, it was noticed that the gear *B* did not go clear on and that there was about $\frac{1}{4}$ in. clearance between the hub and the frame, and someone suggested that it might have something to do with our trouble.

I reasoned that all the thrust would come against the hub of the pinion *C*, but a drowning man will grab at a straw, and as the other gears that broke did not fit up any closer, the order was given to take time to turn the shaft down till there was one thirty-second clearance between the engine frame and the gear.

I could not say that this was what caused us to lose three sets of gears on this engine, but I do know that we had no further trouble while I was at the plant and to my knowledge there has been none since, so it seems reasonable to assume that the end play of the cross-shaft allowed the bevel gear and pinion to mesh too deep, and as the bevel and pinion were steel and the spur gears cast iron, the latter gave way.

I might add that upon investigation it developed that the original cross-shaft had been broken and that a new one had been made locally, which accounts for the gears not going on far enough to allow the proper clearance between the gear hub and the engine frame.

Cherryvale, Kan. EARL PAGETT.

Superheated Steam in Reciprocating Engines

In your issue of July 1, 1919, you inquire as to be use of superheated steam in reciprocating engines. Locomotives furnish the greatest example of such use, for none are built in this country or Canada that do not use highly superheated steam. Moreover, old locomotives are altered to superheaters, and even switching engines are made superheating. Probably it would not be far from the mark to say that there are no saturated-steam locomotives in use in this country. Such locomotives displaced compound locomotives except those of the Mallet type and a few others here and there.

The railroads have had their troubles in developing the use of superheated steam, but with improved lubricants, and metal for cylinder and valve bushings and piston rings, and the use of piston valves (although superheat with slide valves is used), they are out of the woods.

In stationary practice no doubt there are many cases of the use of highly superheated steam in reciprocating engines, but I have used it in pumping and mill engines having Corliss valves, and nothing but a proper lubricant has been necessary for success. The superheat that comes from vertical fire-tube boilers is used in countless reciprocating engines and is a source of some economy. In marine work a superheat of 50 deg. at the boilers is common in ships having reciprocating engines.

On the whole it is safe to say that turbines are not necessary for the use of highly superheated steam, and even they have come to grief from its use in many cases.

Philadelphia, Penn. F. W. DEAN.

Inquiries of General Interest

Test for Acid in Oil—What test of oil can be made for determining the presence of acid? W. R.

Acid may be readily detected by thoroughly mixing a small amount of the oil with an equal quantity of pure warm water. The mixture may then be tested with neutral litmus paper. If acid is present the paper will immediately turn red. The sensitiveness of the paper may be increased by exposing it to fumes of nitric or muriatic acid until it becomes partly red. After the paper thus treated is dried, and part of its surface is immersed in the mixture of water with oil to be tested, the presence of a very small amount of acid will cause the part of the paper immersed to turn a shade darker than the rest.

Size of Ground Wires—For grounding the frames of electrical equipment, what size of ground wire should be used? M. C. R.

Rule 15A(m) of the 1918 edition of the National Electrical Code recommends that with portable equipment protected by fuses not greater than 15 amperes No. 14 ground wire be used. For stationary equipment the protection of which does not exceed 100 amperes a No. 10 B. & S. ground conductor is required. With the nearest cutout protecting the equipment having a capacity of 101 to 200 amperes, use No. 6 B. & S.; where the protection is from 201 to 500 amperes capacity the ground conductor should be a No. 4 B. & S.; above 500 amperes a No. 2 B. & S. conductor is required.

Smokeless Chimney Not Conclusive Proof of Furnace Economy—Is absence of smoke an indication of economical operation of a boiler furnace? W. L. R.

Smokeless combustion indicates more economical operation only when attended by complete combustion of the fuel without too great excess air, and absence of smoke is not conclusive proof that the furnace is being operated in the most economical manner. A very great excess of air may so dilute the smoke as to make it almost invisible, but the efficiency will be low, for under such conditions the furnace temperature is lowered and a large amount of heat is wasted in raising the temperature of the excess air. The true test of economical operation of a boiler furnace is analysis of the flue gas, by which not over 100 per cent. of excess air should be shown.

Use of Sticking Safety Valve—When pressure on a boiler exceeds the allowed pressure from sticking of the safety valve, what should be done to relieve the pressure and how should sticking of a safety valve be guarded against? R. G.

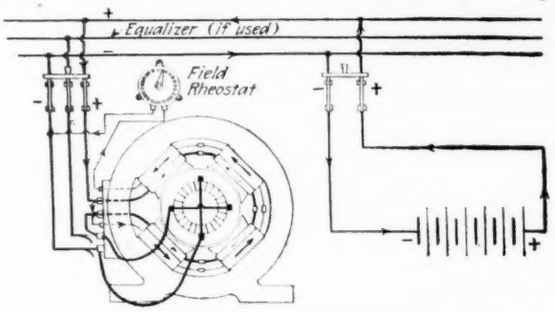
Whenever the boiler pressure is in excess of the allowed pressure, to reduce the pressure increase the speed of the feed pump, close the damper, open as many small outlets for the steam as possible and start slowly all pumps, engines or other available steam apparatus. When the pressure is about normal, slowly lift the safety valve by hand. To guard against sticking of a safety valve it should be allowed to blow at least once a day by raising the pressure to the blowoff pressure, and if there is more than 5 lb. in variation of the blowoff pressure for the same setting, the valve should be thoroughly cleaned and repaired to prevent sticking.

Setting of Piston Valve Having Inside Admission—How would you set a piston valve taking steam in the center, if the valve is connected directly to the eccentric without reversing rocker; and would the eccentric lead or follow the crank, and how much? J. N. A.

Adjust the length of the valve rod or its connections with the eccentric to obtain the same amount of travel of each inside edge of the valve away from the inside edge of its steam port. As in opening, the movement of the valve is opposite to the direction of motion of the piston, when the valve is directly connected the eccentric should be set to follow the crank. If there is no lap or lead the eccentric would be set 90 deg. behind the crank. The angle of advance would be the number of degrees the eccentric would be less than 90 degrees behind the crank for obtaining the desired amount of lead, so that for an inside admission valve with the eccentric directly connected, the eccentric must be set to follow the crank 90 deg. less the angle of advance.

Changing Generator's Polarity—We have a 110-volt storage battery operating in parallel with a 110-volt compound-wound generator. If the polarity of the generator becomes reversed what is the easiest way to establish correct conditions? J. A. W.

One of the best ways to correct the polarity of a generator that has been reversed when operating in parallel with other machines is to open the armature circuit at the machine, the polarity of which is to be corrected, and close its switch to the bus. The connection for this purpose is shown in the figure. This connection will always establish a polarity of the field poles that will bring the generator's voltage up the same polarity as the busbars. Care should be exercised to see that the armature circuit is open, since connecting a dead machine to a live bus is liable to cause serious damage.



Percentage Speed Regulation—What is meant by percentage regulation of a prime mover? E. E. R.

In steam engines, steam turbines and internal-combustion engines, the percentage speed regulation is usually expressed as the percentage ratio of the maximum variation of speed to the rated-load speed, in passing slowly from rated load to no load with constant conditions at the supply. Thus if an engine is carrying full load and the rated-load speed is 200 r.p.m. and the speed increases to 208 r.p.m. when the load is gradually removed, while supplied with steam at the same pressure, the percentage speed regulation would be $8 \times 100 \div 200 = 4$ per cent. If the test is made by suddenly passing from rated load to no load, the percentage speed regulation so derived is termed the "fluctuation." In a hydraulic turbine or other water motor, the governor operates the supply gates only when the normal speed is not satisfied, and the percentage speed regulation is the percentage ratio of the maximum variation of speed, in passing slowly from rated load to no load (with constant head of water) to the rated-load speed.

[Correspondents sending in inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Uses of Superheated Steam*

By Alexander Bradley†

A brief history of the development of superheating, with the results of tests which tend to show the saving of fuel that can be realized by the installation of a properly designed superheater.

In 1705 Denys Papin, the French physicist, made what was probably the first application of superheated steam. By placing a mass of heated metal in a recess of the piston, on the steam side, of Dr. Avery's engine, or pump, he reduced the condensation of the working steam and produced what was in effect a superheater. A certain Captain MacGregor in Cornwall, England, in 1828, built a brick jacket around the cylinder and the steam pipe of his pumping engine; he left a space, or flue, between the brick and the metal, and by maintaining a fire in this space he reduced the steam consumption of his engine to a remarkable extent.

Until about 1870 engineers took great interest in superheated steam. Ericson, Hirn and Isherwood conducted many experiments, securing excellent results. During this period most of the superheaters were installed in connection with marine boilers.

However, about this time vast improvements in the steam engine were introduced—namely compounding, condensing, improved valve gears and, last but not least, higher steam pressures. These improvements, together with the troubles encountered in stuffing-boxes, gaskets and lubrication on superheated steam, tended to limit its use for a number of years. In 1874 Dr. Kirk introduced the triple expansion engine, and it soon became the standard type of marine engine. The steam pressure was still further increased and consequently the temperature, thus militating against superheating under the then existing conditions.

Hirn continued his experiments and in 1892 in a series of tests showed a saving in fuel of 20 per cent. with the superheater installed within the boiler setting. He superheated the steam to from 86 to 113 deg. F. His successors, Schwoerer, Schröter and Schmidt, made rapid strides in again bringing superheating into use. In 1895 Schmidt built a boiler and engine for use with superheated steam, and Prof. Schröter's tests showed that it developed an indicated horsepower upon 10.4 lb. of steam per hour, or about 1.3 lb. of coal. The steam presure was 156 lb. and the superheat 189 deg.

This was a remarkable performance, especially as the engine was of only 75 hp. Soon after the reports of this and other tests were published, interest in superheating rapidly revived, especially in Europe. Lubricating oils, packings and gaskets were brought out which gave perfect satisfaction on superheated steam. During the last ten years pressures have been steadily increasing as has also the amount of superheating, resulting in higher final temperatures.

At about 600 deg. F. cast-iron fittings and valves when used on superheated steam at the present high pressures, are apt to "grow" or expand and then take a permanent set. At somewhat higher temperatures the cast iron begins to lose its strength and becomes in time unable to withstand the pressure. Much apparently conflicting evidence has been submitted upon this subject. After an experience of fifteen years with superheaters and superheating the truth appears to be that cast-iron fittings and valves give good service on superheated steam at 500 to 550 deg. F. if built in the first place of good gray iron and of the proper strength to carry the pressure. If, however, a superheater is employed which gives wide fluctuations in the degree of superheat, the cast iron will "grow" and become "fatigued" in time.

There are many plants that have been in operation for ten years or so, where the cast-iron fittings and valves are still giving good service, and that with pressures up to 175 lb. and superheating up to a final temperature of 525 to 550 deg. F. Until the last few years, cast iron has been the only metal used for this purpose in Europe, where they employ higher pressures and higher superheat than we do in this country, though it should be stated that they claim to be able to produce a much better grade of cast iron than is made here.

Steam, at any given pressure, is said to be saturated so long as it remains in contact with the water from which it is evaporated. If it is now separated from the water and more heat added to it, its temperature increases, it becomes practically a perfect gas and is said to be superheated.

The specific heat of superheated steam, that is the heat required to raise one pound one degree, varies with the pressure and also with the temperature; it increases with the pressure, but decreases as the temperature becomes higher. At 50 lb. absolute pressure the specific heat is 0.498 for 100 deg. superheat, and 0.491 for 200 deg. superheat; while at 250 lb. absolute pressure it is 0.615 for 100 deg. superheat, and 0.562 for 200 deg. superheat.

Being practically a perfect gas, superheated steam follows the laws of gases, its volume increasing with the increase in temperature, and in direct proportion to the absolute temperature. As an example of this characteristic saturated steam at 150 lb. pressure and an absolute temperature of 826 deg. has a volume of 2.75 cu. ft per pound. If this steam is superheated 100 deg. the absolute temperature increases to 926 deg. while the volume increases to 3.08 cu. ft., an increase in volume of 12 per cent. The heat added has been that amount which is necessary to raise the temperature 100 deg., and as the specific heat of superheated steam at 150 lb. pressure and 100 deg. superheat is 0.566, this amount is 56.6 B.t.u. The total heat of saturated steam at 150 lb. pressure is 1227 B.t.u. above zero, hence the 12 per cent. increase in volume has been obtained by increasing the total heat by only 4.6 per cent.

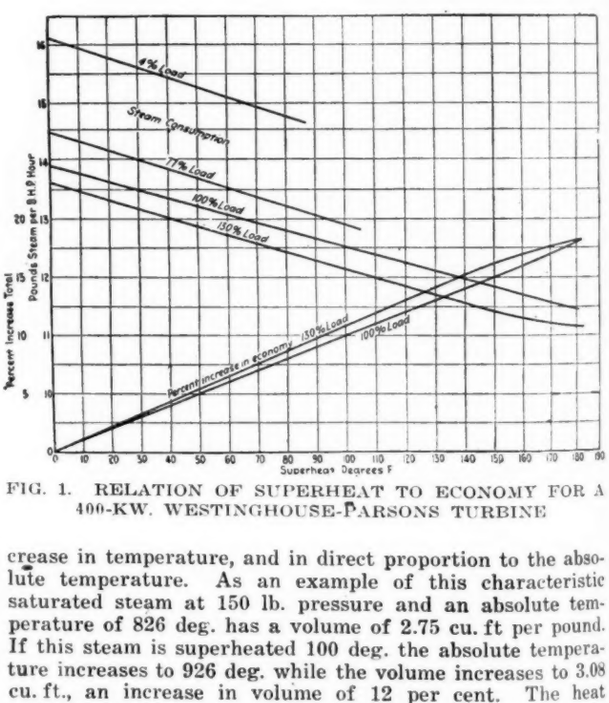


FIG. 1. RELATION OF SUPERHEAT TO ECONOMY FOR A 400-KW. WESTINGHOUSE-PARSONS TURBINE

Steam at any pressure can be superheated, and so long as it remains in connection with the source of supply of saturated steam, the pressure will not increase. As this is the usual operating condition, it may be stated that superheating steam does not increase its pressure.

The following example will serve to show how superheating reduces the steam consumption of an engine: In

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†Power Specialty Co., 111 Broadway, New York, N. Y.

a certain engine (Schmidt) it was found that for each 1 per cent. of wetness, or steam condensed at the point of cutoff, when using saturated steam, it required 7.5 deg. superheat in the entering steam to prevent condensation up to that point. Thus, in case 25 per cent. of the saturated steam condensed at cutoff, there would be required 7.5 deg. $\times 25 = 187.5$ deg. of superheat in order for it to be dry at that stage. Suppose, then, it takes a pound of steam

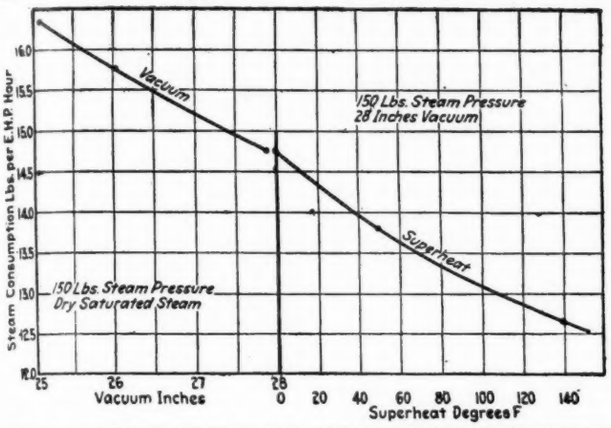


FIG. 2. EFFECT OF VACUUM AND SUPERHEAT ON STEAM CONSUMPTION OF A 1500-KW. TURBINE AT FULL LOAD

to fill this cylinder at cutoff, which would require for its production 1000 B.t.u.; in the first case since 25 per cent. condensation took place, a total of 1¼ lb. was admitted, to produce which takes 1333 B.t.u.; in the second case in addition to the 1000 B.t.u. to produce the steam sufficient heat must be added to superheat it 187.5 deg. and taking the specific heat at 0.48, 90 B.t.u. additional are required.

Since the work performed can be said to be the same in both cases, the heat required is 1333 B.t.u. in the first case and 1090 B.t.u. in the second, or a saving of 23.3 per cent. of the steam by superheating. Thus in an engine, superheating saves by reducing condensation of the steam and loss by radiation through the cylinder walls. On turbines superheated steam shows a decided saving, reduces the wear of the blading to a minimum, and increases the capacity in horsepower.

Fig. 1 gives the relation of superheat to economy on a 400-kw. Westinghouse turbine. Fig. 2 is interesting in that it shows the saving made in a turbine by a vacuum up to 28 in. and by superheating to 150 deg.

In both engines and turbines, however, the guarantees of the builders and the basis of comparisons are upon dry saturated steam upon one hand and superheated steam upon the other. As a matter of fact saturated steam always carries water in actual practice; generally it is found to be what is termed commercially dry and contains about 2 per cent. of water. For each 1 per cent. of water the builder demands a correction in his saturated-steam consumption of 2 per cent. Any reputable builder of turbines or engines will today guarantee 10 per cent. of steam saving if given 100 deg. superheat as compared with dry saturated steam. Therefore as there is in practice 2 per cent. water, 4 per cent. is gained by eliminating the water which, plus 10 per cent. equals 14 per cent., the saving with 100 deg. superheat.

Fig. 4 shows some curves worked out to illustrate the saving in both steam and fuel by superheating—when the saturated steam is dry as well as when it carries 1 per cent. water.

Experience with several hundred engines of the Corliss and slide-valve types indicates that with steam pressure up to 200 lb. it is practical and very beneficial to superheat the steam up to a final temperature of 475 to 500 deg. F., which generally means that there will be a temperature in the steam at the throttle of the engine of from 450 to 475 deg. Piston-valve and poppet-valve engines admit of carrying the superheat much higher and with good economy, although it is generally found that the first 75 to 100 deg. of superheat effects a greater economy than any succeeding like amount.

In a general way it may be stated that the saving in steam and in fuel by using superheated steam on reciprocating engines, pumps and compressors, is as follows, assumings 100 deg. superheat as an amount most frequently used:

	Steam Saving, per Cent.	Fuel Saving, per Cent.
Simple engines and compressors	18	13.5
Compound engines and compressors	14	10.5
Triple engines and compressors	12	9.0
Simple direct-acting pumps	22	16.5
Compound direct-acting pumps	18	13.5
Triple direct-acting pumps	16	12.0

A few years ago a comparative test was run by the engineers of the United States Steel Corporation at one of its plants in order to ascertain what saving could be made in the steam consumption of a large Allis-Chalmers cross-compound blowing engine. The result showed an average saving of 13.33 per cent. with 113 deg. superheat, and this, too, upon a very economical engine. There were several different types of engines tested, and the entire series were very well conducted and the results most interesting. The Standard Oil Co. recently ran a series of comparative tests at its Malby station on direct-acting triple-expansion oil-pumping engines. Fig. 3 gives the results obtained in two groups of curves, one on saturated steam, the other on superheated steam. The results were highly satisfactory as the curves show—at the average power load on the plant the saving in water fed to the boilers (this plant is in the desert) was 20.5 per cent., the saving in dry steam on the main pumps was 10.93 per cent. and in fuel (dry oil) fed to the boilers 15.95 per cent.

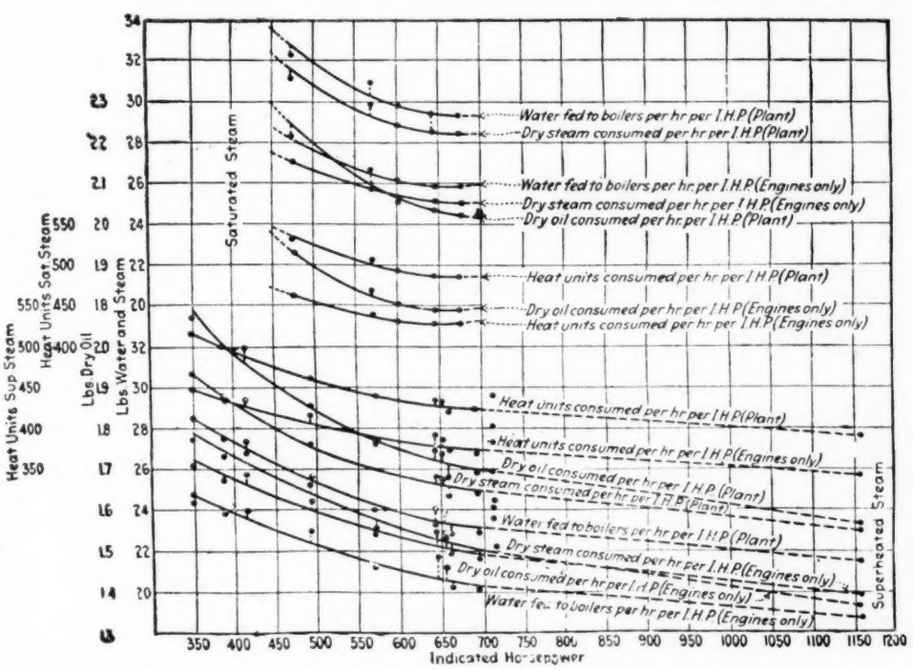

Saturated Steam
Superheated Steam
Heat Units Sup Steam
Heat Units Sat Steam
Lbs Dry Oil
Lbs Water and Steam
Water fed to boilers per hr per I.H.P (Plant)
Dry steam consumed per hr per I.H.P (Plant)
Water fed to boilers per hr per I.H.P (Engines only)
Dry steam consumed per hr per I.H.P (Engines only)
Dry oil consumed per hr per I.H.P (Plant)
Heat units consumed per hr per I.H.P (Plant)
Dry oil consumed per hr per I.H.P (Engines only)
Heat units consumed per hr per I.H.P (Engines only)
Indicated Horsepower

FIG. 3. RESULTS OF COMPARATIVE TESTS ON OIL-PUMPING ENGINES WITH SATURATED AND SUPERHEATED STEAM

It should be borne in mind that the total saving is not made in the prime movers, to be mostly offset by the cost of the additional fuel required to obtain the superheat. A properly designed superheater attached within the setting of a boiler always results in at least as good an efficiency for the combined boiler and superheater as for the boiler alone; generally, the combined efficiency is higher, and often to such an extent that the first 50 deg. of superheat are obtained without the expenditure of additional fuel.

Being a perfect gas, superheated steam can be put through pipes at a higher velocity than is possible with

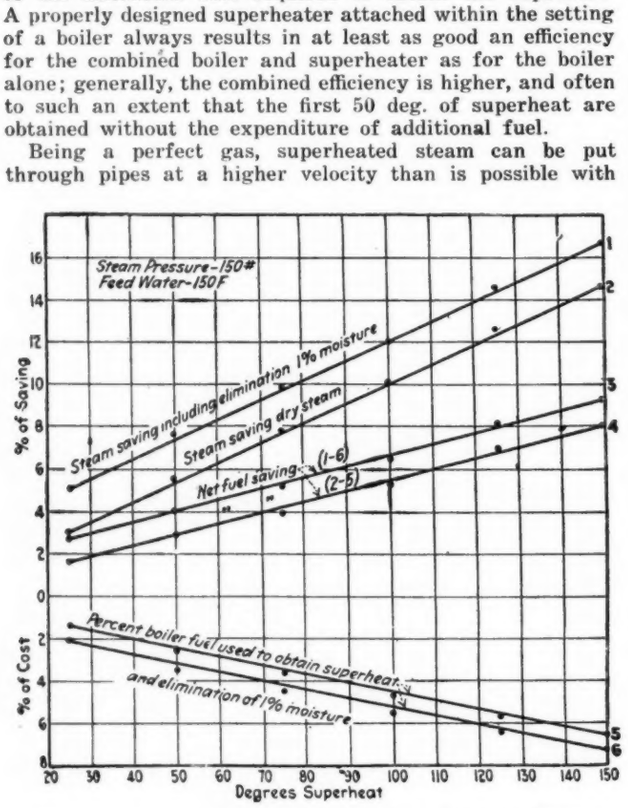


FIG. 4. DIAGRAM SHOWING SAVINGS DUE TO SUPERHEAT IN TURBINES

saturated steam at the same pressure. This means smaller pipes and fittings at a corresponding saving in this material. The loss in pressure in a long pipe line is also less when the steam is superheated.

During the past few years a number of interesting uses for superheated steam have been developed. The Peoples Gas Light and Coke Co., of Chicago, is blowing its water-gas generators with superheated exhaust steam at about 2.5 lb. pressure, instead of using live steam as heretofore. The saving averages 20 per cent. with a satisfactory increase in the capacity of the generators themselves. The use of superheated steam has been successfully introduced in the manufacture of wood pulp. Also textile mills, sugar mills, oil refineries, salt works and plants of a similar nature have found that it pays.

Proposed Legislation to Strengthen Patent Office

As is known to representatives on Engineering Council, the Patents Committee of Council has collaborated with the similar committee of National Research Council in developing a scheme for the improvement of the method of dealing with patents in this country. The staff of the Patent Office is itself actively engaged in this effort. Out of the report prepared by the National Research Council, and approved and adopted by Engineering Council as the report also of its Patents Committee, remedial legislation has taken form. Three bills have been introduced, known as H. R. 5011, a bill to make the Patent Office independent of the Department of the Interior or any other department, and to simplify the procedure of the Courts with reference to assessment of damages or profits for infringement of patents; H. R. 5012, a bill to establish a single Court of Patent Appeals; and H. R. 7010, a bill to increase the force and salaries in the Patent Office.

Oxy-Acetylene Welding*

BY ALFRED S. KINNEY †

Up to the advent of autogenous welding the engineer had only his experience with the forge weld upon which to base his calculations and judgment. In a way this proved somewhat unfortunate for the new method of welding, as the forge weld had nearly lost its value as a dependable means of joining materials. Imagine two pieces of steel being brought to a soft plastic condition in a forge fire charged with sulphur from the fuel, an excess of oxygen from the indifferently operated bellows or fan blower, the cinders and refuse of the fuel, and one can readily realize the cause of weak forge welds. Such welds never were reckoned to have a tensile efficiency of more than about 50 per cent., and many observations of welds which had failed showed crystallization and even entrapped cinders. Navy yards and many other large shops had practically abandoned the forge weld, preferring the expensive substitute of machining a job out of the solid when it was possible to do so.

Then, too, in those earlier days the only metals which could be welded were wrought iron and steel. There was no way to weld cast iron and the non-ferrous metals like copper, brass, aluminum.

Then came autogenous welding and cutting by the oxy-hydrogen process, soon to be superseded by oxy-acetylene, thanks to the electric furnace's efficient method of producing calcium carbide and making acetylene a commercial possibility. From that time—practically only about fifteen years ago—metal workers, manufacturers, engineers—nearly the whole industrial world have eagerly watched the progress of the oxy-acetylene process.

CONDITIONS OF METAL CONTRASTED

The mechanical engineer recognized at once that certain fundamental principles were involved in oxy-acetylene welding which were new to shop practice. The old method required that the metal be heated merely to a soft pasty condition and then hammered or pressed together, while the new way was to melt the metal and flow the two ends into one mass. By the former method there would not be a thorough mingling of the grains of the metal, and every opportunity for such a weld to receive gas and fuel impurities from the forge fire. By the new process there could be nearly perfect rearrangement of the grains due to the liquid condition of the metal. The mechanical engineer recognized at once, however, that while the fusion of castings for welding would be consistent with the method of their formation, that is, that both the original metal and the weld itself would be in the cast condition, this would not be true in the case of the welding of rolled or forged iron or steel. There the two pieces of rolled or forged metal would be joined by a cast weld, the former being fine grained and strong, the latter of coarse grains and reduced tensile strength. This was not a new situation to the engineer. The benefits derived from hammer-refining the grains of steel are well known. An ordinary machinist hammer therefore proved to be the cure of this trouble, and it may be of interest to relate that in some experiments performed during the past year by the author, some worn railroad frogs which were built up by the oxy-acetylene process, and allowed to cool directly from the liquid to the solid condition lasted only a few weeks in service, but when a progressive method of building up and hammering was resorted to some of the frogs lasted over nine months in continuous severe service.

As fusion was the chief requisite of a good weld, the new process might be used to join other metals than wrought iron and steel. This opened up wonderful possibilities, new indeed to welders, for cast iron and the non-ferrous metals had not yet been welded. Would it be possible for the new welders to learn the marked differences of characteristics of steel, cast iron, copper, brass, aluminum? We

*From an address before the International Acetylene Association.

†Professor of Shop Practice, Stevens Institute of Technology and Advisory Engineer Air Reduction Company.

have but to call to mind the work being done in the welding of iron castings alone to get an answer and to form an idea of the possibilities and value of the oxy-acetylene process for the welding of cast iron. The author recently had to do with the oxy-acetylene welding of three broken cast iron cylinders of freight locomotives, which cost $515 to weld and put in good working order, but would have cost $3,600 to replace by new cylinders if oxy-acetylene welding had not been available, leaving out of consideration the long delay in getting the locomotives back in service by the old method of making repairs, as compared with the few days lay up for welding.

The gases used in an oxy-acetylene torch operated by inexperienced welders might easily be made to lower the value of the weld. Many of the first oxy-acetylene welds were badly crystallized. The engineer knew this and waited for developments. The first designs of torches were much to blame for this condition, but the inexperience of the welder was more so. It is not unusual now to find oxy-acetylene welds so homogeneous as to make it practically impossible to see any difference between the original material and its weld.

Unusual problems of expansion and contraction must be reckoned with in the job welded by oxy-acetylene. No one would attempt to dispute this. The cautiousness of the engineer in this regard may well be understood. It has required an experimental experience to master these difficulties, but they do not stand in our way now.

Proper Training of Workmen Essential

The heating of the oxy-acetylene weld was accomplished by the powerful quick-acting flame instead of a slow forge fire. It was readily seen that a trained eye would be required to bring about good results from the working of the metal in the molten conditions. What would happen if the metal were overheated? What if the original metal were not thoroughly melted when the molten rod was dropped upon it? A man must know more than a blacksmith about hot metals to be an oxy-acetylene welder. Could such men be secured and could their skill be relied upon? We know the answers to these questions now, but they recall to some at least the time of not so long ago when the mechanical engineer struggled with his welders to teach them the difference between molten metal and burnt metal. We venture to say that it will be much easier to make good oxy-acetylene welders from now on than it has been heretofore.

To continue this subject a bit further it will be apropos to call attention to the attitude of the technical engineer toward the teaching of the oxy-acetylene processes in the engineering colleges. Some of these institutions were not slow to grasp the importance of the subject. The Stevens Institute of Technology was probably the first college to take up the work. The author has lectured for about ten years on the subject as head of the Department of Shop Practices in that institution, and some time ago we added a course of jobs to be welded by the oxy-acetylene torch which every student at Stevens has been required to take. We have heard of other engineering colleges who have introduced such a course, and we understand that Harvard's new engineering school is about to include oxy-acetylene welding in the instruction of its shop department.

Abroad in the world of engineering construction and repairs the technical engineer has been giving careful thought to the possibilities and advantages of oxy-acetylene welding. He has encouraged its trial in shop, foundry, and manufacturing plant. He has studied its evolution from the rough joint of doubtful value to the homogeneous weld of nearly 100 per cent efficiency. If he has been conservative in his judgment it was because he knew better than others of the undeveloped parts of the new field being entered by the welder; if he has appeared to be slow to accept the process for the most important high pressure and high tension work it is because he has waited to prove that the new welder could measure up to his increased responsibility. One thing he will not do: he will not forget the inherent crudeness of the work, nor the varying personal error of the workmen, and expect impractical refinements.

The Production of Electric Power

The United States Geological Survey has issued a bulletin in which the production of electric power and consumption of fuel by public utility power plants in this country is given for the month of March, 1919.

The report is based on returns received from 3075 electric power plants engaged in public service, including central stations, electric railways, and certain other plants, the output of which contributes to the public supply. Returns were received from plants representing about 89 per cent. of the total generating capacity. For those plants which did not submit returns or were unable to furnish their output, estimates of the output were made as accurately as possible from available information. The output for the month averages 101,400,000 kilowatt-hours per day of which 41 per cent. was produced by water power. The average consumption of coal per kilowatt-hour of plants using coal, which made returns, was about 3 pounds.

THOUSANDS OF KILOWATT HOURS PRODUCED

State	By Water-Power	By Fuels	State	By Water-Power	By Fuels
Alabama	30,275	4,907	Nevada	2,450	121
Arizona	6,689	21,807	New Hampshire	7,971	1,958
Arkansas	72	6,620	New Jersey	197	76,775
California	215,914	33,939	New Mexico	56	1,556
Colorado	14,254	17,144	New York	222,318	288,191
Connecticut	14,884	37,469	North Carolina	46,333	7,425
Delaware	0	4,784	North Dakota	0	2,453
District of Columbia	0	19,172	Ohio	3,932	194,850
Florida	892	8,789	Oklahoma	183	12,981
Georgia	37,264	6,082	Oregon	29,014	3,779
Idaho	39,913	257	Pennsylvania	62,509	246,989
Illinois	15,282	207,705	Rhode Island	805	18,405
Indiana	3,648	54,613	South Carolina	43,417	4,045
Iowa	48,502	25,051	South Dakota	3,579	4,042
Kansas	1,223	30,775	Tennessee	45,222	10,680
Kentucky	4	19,127	Texas	200	48,034
Louisiana	0	14,866	Utah	15,463	0
Maine	20,157	73	Vermont	18,393	179
Maryland	371	13,898	Virginia	20,221	18,774
Massachusetts	31,365	100,034	Washington	79,347	4,521
Michigan	59,650	96,101	West Virginia	1,593	58,108
Minnesota	34,881	16,848	Wisconsin	37,569	33,053
Mississippi	0	5,399	Wyoming	172	3,898
Missouri	5,920	38,396			
Montana	77,861	854	Total	1,300,924	1,842,214
Nebraska	959	16,687	Combined total		3,143,138

FUEL CONSUMPTION

State	Coal, Short Tons	Petroleum and Derivatives, Barrels	Natural Gas, Thousands of Cubic Feet
Alabama	16,467	0	0
Arizona	6,160	88,011	0
Arkansas	11,177	489	85,398
California	0	185,127	181,785
Colorado	44,079	95	0
Connecticut	62,234	323	12,615*
Delaware	7,713	17	0
District of Columbia	20,483	0	0
Florida	5,594	199,149	151
Georgia	11,934	120	0
Idaho	111	10	0
Illinois	351,289	2,198	0
Indiana	157,896	167	2,108
Iowa	78,739	730	0
Kansas	51,932	60,233	85,996
Kentucky	39,386	351	0
Louisiana	14,560	29,419	47,458
Maine	348	7	0
Maryland	23,657	18	1,500
Massachusetts	143,453	14	0
Michigan	124,841	104	0
Minnesota	46,346	992	0
Mississippi	16,542	349	0
Missouri	90,495	19,580	0
Montana	5,686	563	960
Nebraska	32,984	3,349	0
Nevada	180	1,044	0
New Hampshire	3,696	20	0
New Jersey	116,525	103	0
New Mexico	4,438	1,360	0
New York	363,319	546	164,408
North Carolina	16,234	20	0
North Dakota	17,116	504	0
Ohio	321,987	842	323,020†
Oklahoma	13,153	5,594	440,094
Oregon	433	14,345	0
Pennsylvania	408,264	14	54,450
Rhode Island	22,024	0	0
South Carolina	9,540	33	0
South Dakota	12,325	3,463	0
Tennessee	28,724	84	0
Texas	34,789	181,318	179,760
Utah	61	0	0
Vermont	412	2	0
Virginia	22,475	13	0
Washington	3,473	18,804	0
West Virginia	70,717	58	142,688
Wisconsin	77,139	662	0
Wyoming	19,907	2,539	18,349
Total	2,931,037	822,783	1,740,740

* Artificial gas. † 67,156 artificial gas.

A. I. E. E. Committee Appointments

At the first meeting of the Board of Directors of the American Institute of Electrical Engineers for the administrative year beginning on Aug. 1, 1919, held in New York, on Tuesday, Aug. 12, 1919, President Townley appointed committees for the administrative year, the chairmen of which are as follows:

Finance, N. A. Carle, Newark, N. J.; Meetings and Papers, W. I. Slichter, New York; Editing, Henry H. Norris, New York; Board of Examiners, F. L. Rhodes, New York; Sections, W. A. Hall, Lynn, Mass.; Student Branches, C. Francis Harding, Lafayette, Ind.; Membership, R. W. Krass, New York; Public Policy, H. W. Buck, New York; Headquarters, N. A. Carle, Newark, N. J.; Committee on Technical Activities, Wilfred Sykes, Pittsburgh; Standards, L. T. Robinson, Schenectady, N. Y.; Power Stations, Philip Torchio, New York; Transmission and Distribution, E. B. Meyer, Newark, N. J.; Traction and Transportation, W. S. Murray, New York; Industrial and Domestic Power, A. G. Pierce, Pittsburgh; Lighting and Illumination, C. E. Clewell, Philadelphia; Economics of Electric Service, William McClellan, Philadelphia; Protective Devices, D. W. Roper, Chicago; Electrochemistry and Electrometallurgy, E. F. Northrup, Princeton, N. J.; Electrophysics, F. W. Peek, Pittsfield, Mass.; Telegraphy and Telephony, Donald McNicol, New York; Marine, Arthur Parker, Camden, N. J.; Use of Electricity in Mines, W. A. Chandler, Uniontown, Pa.; Electrical Machinery, B. A. Behrend, Boston; Instruments and Measurements, S. G. Rhodes, New York; Iron and Steel Industry, W. F. James, Philadelphia; Educational, J. C. Parker, Ann Arbor, Mich.

In accordance with the by-laws of the Edison Medal Committee the board confirmed the appointment by President Townley of three members of that committee for terms of five years each; namely, Messrs. Edw. D. Adams, New York; H. H. Barnes, Jr., New York; and Benjamin G. Lamme, Pittsburgh; the Board also elected three of its own membership as members of the Edison Medal Committee for terms of two years each, namely Messrs. Wilfred Sykes, Pittsburgh; W. A. Hall, Lynn, Mass.; and G. Faccioli, Pittsfield, Mass.

Exports of Electrical Machinery and Appliances for May, 1919*

Countries	Batteries Dollars,	Dynamos and Generators Dollars	Fans Number	Fans Dollars	Incandescent Lamps, Carbon Number	Incandescent Lamps, Carbon Filament, Dollars	Incandescent Lamps, Metal Filament, Number	Incandescent Lamps, Metal Filament, Dollars	Insulated Wire and Cables, Dollars	Transformers, Dollars	All Other Electrical Machinery, Dollars	Meters and Measuring Instruments, Dollars	Motors, Dollars	Rheostats Controllers, Dollars	Switches and Accessories, Dollars
Belgium	75	15,627	.....	.....	1,000	210	2,000	620	53	2,370	39,177	.....	9,594	.....	45,058
Denmark	2,042	.....	.....	.....	.....	.....	23,000	7,410	9,357	5	18,593	2	.....	.....	.....
France	3,453	9,528	.....	.....	.....	.....	.....	.....	4,431	5,234	88,712	5,367	20,861	800	14,944
Greece	100	.....	.....	.....	.....	.....	.....	.....	670	.....	1,806	.....	485	.....	.....
Iceland and Faroe Islands	1,289	2,893	.....	.....	.....	.....	1,300	687	212	.....	1,773	.....	124	350	4,651
Italy	87	.....	.....	.....	.....	.....	77,982	21,796	110	.....	430,407	7,672	.....	.....	.....
Netherlands	.....	.....	.....	.....	.....	.....	.....	.....	315	.....	1,169	.....	.....	.....	340
Norway	11,420	.....	.....	.....	.....	.....	40	12	133,350	32,831	45,618	71	9,029	.....	7,669
Portugal	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	.....	.....	.....	.....
Spain	1,350	1,605	270	2,395	.....	.....	6,150	1,620	.....	2,198	26,800	484	21,722	50	3,664
Sweden	.....	.....	.....	.....	.....	.....	.....	.....	6,752	.....	38,727	.....	3,169	.....	.....
Switzerland	.....	.....	.....	.....	.....	.....	.....	.....	49,812	.....	123,213	577	9,178	.....	20,642
England	70,222	2,808	.....	.....	.....	.....	300	700	6,178	.....	39,746	7,418	25,032	387	930
Scotland	.....	9,200	.....	.....	.....	.....	.....	.....	.....	.....	117	.....	50	.....	.....
Bermuda	55	.....	15	300	.....	.....	130	39	27	.....	377	1,500	291	.....	348
British Honduras	495	100	1	28	.....	.....	558	543	407	.....	313	.....	.....	.....	26
Canada	143,840	75,006	1,075	14,532	15,859	1,810	201,959	97,529	5,548	5,667	551,791	28,966	126,954	25,116	34,816
Costa Rica	245	.....	.....	.....	.....	.....	11,230	2,973	959	2,125	3,899	.....	537	.....	.....
Guatemala	1,037	2,344	.....	.....	1,000	176	13,000	3,048	402	2,218	1,552	12	2,732	62	.....
Honduras	720	42	7	200	.....	.....	2,201	717	85	.....	4,798	75	409	267	.....
Nicaragua	640	700	.....	.....	.....	.....	1,600	387	441	.....	599	86	.....	.....	71
Panama	3,746	5,924	12	144	1,454	348	8,416	3,041	2,070	1,110	9,225	2,822	17,911	326	177
Salvador	986	.....	.....	.....	1,196	457	3,404	1,704	267	4,464	2,781	223	1,851	25	.....
Mexico	22,641	3,722	526	10,500	2,700	836	221,940	44,433	28,651	42,949	103,498	5,328	14,019	1,455	4,368
Newfoundland and Labrador	6,769	729	.....	.....	.....	.....	556	407	3,281	91	5,467	373	582	.....	561
Barbados	147	.....	.....	.....	.....	.....	700	211	19	.....	139	.....	420	.....	94
Jamaica	1,043	.....	2	42	.....	.....	759	239	757	6	3,475	32	324	.....	365
Trinidad and Tobago	453	.....	.....	.....	.....	.....	5,290	1,699	82	.....	3,600	651	28	27	22
Other British West Indies	218	.....	.....	.....	.....	.....	210	141	475	.....	1,630	.....	400	.....	9
Cuba	20,919	19,742	158	4,663	2,600	582	53,206	19,857	62,567	3,226	99,704	15,220	44,086	893	13,228
Dutch West Indies	52	.....	.....	.....	100	20	50	72	168	.....	14	.....	300	.....	.....
French West Indies	227	.....	5	124	.....	.....	104	19	86	.....	318	23	.....	.....	.....
Haiti	420	.....	.....	.....	.....	.....	95	65	96	.....	60	47	.....	.....	79
Dominican Republic	369	.....	.....	.....	.....	.....	2,894	1,235	1,124	76	1,462	.....	446	.....	.....
Argentina	12,156	.....	40	750	.....	.....	16,533	4,790	40,070	.....	23,551	16,256	1,060	.....	1,386
Bolivia	.....	.....	.....	.....	350	162	2,888	3,424	2,346	.....	9,827	.....	5,581	115	420
Brazil	11,573	22,523	55	1,240	375	164	255,469	54,841	140,341	21,491	163,963	19,184	88,873	1,853	18,437
Chile	6,060	.....	.....	.....	2,000	285	29,041	10,552	41,400	8	84,603	928	10,991	497	10,335
Colombia	673	884	56	965	.....	.....	63,547	14,468	6,032	3,378	12,311	695	1,234	38	843
Ecuador	5,987	439	.....	.....	.....	.....	19,756	5,514	1,662	.....	1,625	.....	2,393	.....	679
British Guiana	728	.....	.....	.....	.....	.....	2,724	718	630	94	1,478	.....	106	.....	.....
Dutch Guiana	.....	.....	.....	.....	.....	.....	474	177	156	.....	12	.....	.....	.....	.....
Peru	2,882	3,198	.....	.....	500	71	21,968	8,677	21,103	7,914	28,706	490	14,343	284	2,298
Uruguay	5,042	65	.....	.....	.....	.....	11,930	4,297	93,578	3,608	61,556	125	8,851	292	3,548
Venezuela	2,593	542	.....	.....	1,680	275	17,700	3,276	1,713	278	4,545	25	71	5	.....
China	3,484	9,526	3,548	109,768	341,183	36,317	4,539	2,048	8,451	24,089	25,048	6,856	30,570	677	12,084
Japanese China	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	396	.....	.....	.....
British India	13,050	3,756	809	23,024	.....	.....	26,225	8,244	122	56,300	81,393	549	36,144	7,258	1,661
Straits Settlements	225	68	38	525	2,000	240	4,320	1,462	535	66	3,614	.....	16,445	120	9
Other British East Indies	65	.....	.....	.....	.....	.....	4	1	109	.....	1,086	5	135	.....	.....
Dutch East Indies	10,864	800	12	64	.....	.....	6,350	945	78,890	6,717	11,054	2,522	6,799	1,262	.....
French East Indies	.....	.....	10	342	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hongkong	1,742	4,199	188	4,175	.....	.....	2,676	1,125	34	8,179	7,011	271	1,199	.....	238
Japan	5,856	17,048	792	12,326	.....	.....	300	126	2,561	568	102,089	104,639	29,242	226	3,470
Russia in Asia	.....	.....	.....	.....	.....	.....	.....	.....	813	.....	.....	2,234	1,800	.....	.....
Siam	4,686	420	.....	.....	.....	.....	358	300	41	13,118	4,707	.....	3,774	.....	5,782
Australia	30,112	12,443	70	1,153	1,700	515	180,576	45,133	17,965	43,495	161,596	9,943	179,107	7,203	35,181
New Zealand	20,912	14,666	.....	.....	100	26	19,469	5,265	.....	1,622	38,950	2,076	18,093	8,456	2,189
Other British Oceania	840	.....	.....	.....	.....	.....	.....	.....	.....	.....	24	.....	.....	.....	.....
French Oceania	846	.....	.....	.....	.....	.....	1,400	700	.....	.....	180	.....	.....	.....	.....
German Oceania	388	.....	.....	.....	.....	.....	48	12	.....	.....	.....	.....	.....	.....	.....
Philippine Islands	10,958	7,478	527	11,759	8,000	1,663	138,874	37,095	31,954	15,046	77,067	116	16,483	4,925	3,216
British West Africa	686	620	.....	.....	.....	.....	.....	.....	27	.....	895	.....	84	.....	.....
British South Africa	68,374	4,081	56	1,659	.....	.....	46,857	10,017	28,903	15,260	44,799	1,330	30,313	791	350
British East Africa	120	.....	.....	.....	.....	.....	.....	.....	.....	.....	185	.....	329	.....	.....
French Africa	.....	.....	30	447	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Portuguese Africa	27	5,179	.....	.....	.....	.....	1,920	483	.....	423	7,299	.....	2,444	673	.....
Total	516,001	257,908	8,302	201,125	383,797	44,157	1,515,020	434,894	838,188	326,224	2,609,750	245,589	816,981	64,433	254,188

* Compiled by the Bureau of Foreign and Domestic Commerce of the Department of Commerce.

Rehabilitation of the Ex-Soldier

Many of the young men who were drawn into the Army or Navy had graduated from public school or high school just a few years ago, and, like millions of others, had drifted into some blind alley where they never could advance and where they simply ground away the hours from Monday to Saturday, week in and week out, says Major Warren Bigelow, U. S. A., Director of the Re-employment Bureau of New York City for Soldiers, Sailors and Marines. The war came; they were drawn into the service; they got abroad; they even saw Paris—the great Paris; they saw the trenches; they worked and they suffered, but they have come back with more vision and a bigger outlook than they had before. They are not satisfied now to go back into the old blind alley that leads nowhere and pays the same price year after year.

But they don't know what to do. They don't know what they are fitted for besides the thing they have always done. As one man said to me, "When I had kept the books all day they were straight at night, but that is as far as I ever got." And there is the stock room clerk, the helper, the porter, the shipping clerk, who makes out bills and tags. Even if they wanted the same old job we couldn't find enough jobs for them in New York to go around.

We have to rehabilitate these men. I don't mean the wounded men; I mean the men who come back with more vision and desire to do better things than they did before. To that end we have established at this Bureau a vocational department where men who understand a bit of psychology and are skilled in the knowledge of trades, talk with a man and advise him what he can take up, what he is fitted for, and what is open to him. These men are trying to help the ex-service man realize his larger vision, the increased sense of individual power, and the better sense of proportion that he has brought back with him after facing the elemental facts of life. The employer can help us, and in doing so will in a measure repay the debt he owes to those who fought for him; he can make room for these men and can give them a fighting chance to make good and to learn a trade with a decent living wage while they are learning it.

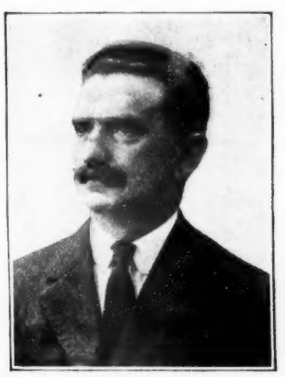
We have taken these things up with various unions and they have expressed a desire to help us train these men. They are mostly beyond the ordinary age of apprentices, but the old system of apprenticing a man at 16 years of age has largely passed away and now with the intensive training by highly specialized methods a man can learn his trade in much shorter time than heretofore.

What we want are more opportunities for men to learn trades. We have already sent 1544 unskilled men to apprenticeships and we have induced 910 so-called clerks to change their vocation and learn a trade. This work must go on and to do it we need opportunities for men to learn things. The employer must not content himself with taking back his old employees. He must make new opportunities and send them in to us. I speak of the trades, but there are opportunities in other lines. Take a man on and teach him to be a salesman; teach him to be an executive; teach him your business and I know you will find the fighting blood will make good. All kinds went into the Army and all kinds are coming out; here and there you may have an unfortunate experience, but by and large, the men coming out are just a little better than they were when they went in.

I cannot over-emphasize the urgent need we have for learners' jobs in all trades and in all callings.

Thomas H. Cole

Thomas H. Cole, prominent in power engineering circles, died at the Brooklyn (N. Y.) Hospital on Sunday, Aug. 24, in his fifty-second year. Mr. Cole was born in Tarryville, N. Y., and went to live in Brooklyn when a young man. His death was the result of an accident in the plant of the Benjamin Moore Paint Co., where he was employed as chief engineer for twenty-eight years. Mr. Cole was a charter member of the Brooklyn, N. A. S. E. No. 41, and was a delegate to the annual conventions for the past twenty-two years. He was also a member of Commonwealth Lodge No. 409, F. and A. M.; Long Is. Grotto No. 44; Reliance Tent No. 851, K. O. T. M. and the Order of Moose. The Masonic funeral services were conducted at his late home, 713 Decatur Street, Brooklyn, on Tuesday evening, and the interment was at Greenwood Cemetery, on Wednesday morning. Mr. Cole was highly esteemed and his absence will be felt by a host of friends. He is survived by his widow, two sons, his mother, two sisters and three brothers.



THOS. H. COLE

New Publications

McGraw Central Station Directory and Data Book. McGraw-Hill Co., Inc., New York. Cloth, 4¼ x 8½ in.; pages 833. Price $15.

This is the 1919 edition of this book, which is published annually. It is practically an encyclopedia of the electric-lighting industry. In the case of each company it gives the name and location, the owners or controlling interests, capitalization, bonded indebtedness, names of the officers and their addresses, details as to the number and size of the electrical and steam units in the plant, the lighting load and its rates, the cost of fuel and the territory served. The information is given in condensed form and arranged according to states, the names of the cities and towns being in alphabetical order. It thus forms a complete inventory of the central-station equipment of the country, as well as of Canada, Mexico and the West Indies. It is of great interest and value to manufacturers of power-plant equipment and electrical appliances, holding companies, financial institutions and public-service commissions.

"Boiler Safety," a new booklet just off the presses of the Travelers Indemnity Co., Hartford, Conn., is a sister booklet to "Boiler Economy," recently issued by that company. Its purpose is to describe approved ways of preventing accidents in the boiler room. It is a convenient pocket-size, and will be a handy reference book for the engineer and fireman, as well as the plant-owner. In 175 pages, the subject matter is divided up into forty sections, each of which relates to some particular phase of boiler room work, or to the care and operation of certain equipment or apparatus in the boiler room.

The first section is headed "Putting Boilers in Service," and covers all the principal operations necessary to making sure that everything is in safe and satisfactory condition for starting up. In short, it is a practical book for practical men. Its language is clear and concise, and although it covers its ground thoroughly, there are no formulas or theoretical discussions to discourage the man with a limited education. There are also thirty-two illustrations which show the results of boiler explosions, defective parts of boilers, approved power-plant equipment, and other subjects of interest to engineers.

Engineering Affairs

The Association of Iron & Steel Electrical Engineers will hold its thirteenth annual convention at St. Louis, Sept. 22-26.

The Pennsylvania Electric Association will hold its twelfth annual convention at Bedford Springs, Penn., Sept. 3-6. Among the papers to be presented of interest to *Power* readers are the following: "The Effect of the War on Boiler-Room Practice for Medium-Sized Plants;" "Isolated Plant Costs as Influenced by the War;" "Power-Factor Correction by Means of the Static Condenser."

Personals

N. S. Braden, formerly sales manager of the Canadian Westinghouse Co., Ltd., Hamilton, Ont., has been elected vice president of the company.

Herman G. Hardy, formerly connected with the Old Hickory Powder Plant at Jacksonville, Tenn., is now chief mechanical and electrical engineer of the Arizona Copper Co., Ltd., Clifton, Ariz.

E. Caldwell has resigned as secretary of Philadelphia No. 12, N. A. S. E., after thirty-one years of service. The Association presented him wtih a beautifully engraved set of resolutions upon his retirement, and in conjunction with Vulcan Assembly gave him an outing at Fairmont Park, to which many of his friends were invited.

Captain Edward Van Winkle recently of the Engineers Corps announces his association with Frederick A. Waldron, Consulting Engineer, 37 Wall St., New York City, for the general practice of engineering with especial reference to the problems relating to the construction, development, and operation of industrials. Captain Van Winkle served 18 months in France, Belgium, Luxemburg and Germany and was in the Argonne and St. Mihiel offensives. While with the American Expeditionary Forces he was Engineer Officer of the Construction Troops which built the largest engineer depot in the advanced area, located at Issurtielle, being in charge of most of the design and of the field parties of this nineteen million project.

Business Items

The Fisher Governor Co., Marshalltown, Iowa, has opened a New York City office at 1 Franklin St., with P. L. Rhodes in charge.

The Jeffrey Manufacturing Co. Columbus, Ohio, has opened a branch office in the Book Building, Detroit, with O. B. Wescott in charge.

The Automatic Furnace Co., Dayton, Ohio, has opened a branch office at 231 Insurance Exchange Building, Chicago, with Alfred J. Saxe in charge.

The Dover Boiler Works, Dover, N. J., one of the oldest plate metal works in the East, has opened an office in the Franklin Trust Building, Philadelphia, with Henry F. Vaché in charge.

Geo. B. Allen & Co., the Texas representatives of the Vulcan Soot Cleaner Co., have removed from Houston, Texas, to Dallas, Texas, where they can be reached by mail temporarily at P. O. Box 720. Mr. Allen is a fuel economy specialist of many years experience.

The Hofmann-Sproul Co., Philadelphia, Penn., announces that the following men have joined its organization: E. R. Doud, formerly with the Tioga Steel and Iron Co., and with the Bethlehem Steel Co.; E. R. Campbell, formerly with the American Steel Foundries, and Walter Maccallum, chemical engineer.

The Chicago Pneumatic Tool Co. plans moving its general offices from Chicago to New York and toward this end is erecting a ten-story combination steel, brick and limestone office building at 6-8 East 44th St., New York City, which will be ready for occupancy early in 1920. There will be continued in Chicago a sales and service organization more extensive than formerly. The company also announces the removal of its Cincinnati office from the Mercantile Library Building to the Walsh Building, Pearl and Vine Sts., where a service station with complete stock will be maintained.

The Pierce Fuse Corp., Buffalo, N. Y., announces the following changes in its personnel: Hight & Stout will represent the company at 345 Fifth Ave., New York City; A. H. Nickerson, formerly of the Adapti Co., is the Cleveland (Ohio) representative, with offices at 310 Lenox Building; Glenn A. Wilson, formerly with the Franklin Incandescent Lamp Co., has taken over the Pierce Fuse Co.'s account in Syracuse, Rochester, Albany, Wilkesbarre, Binghamton and Batavia; R. S. Blake has been placed in charge of the new office in Chicago, at 322 Sherman St., and will take care of that territory.

Trade Catalogs

The Star Brass Works, Chicago, Ill., has just issued a twenty-four-page bulletin, No. 5, covering atomizing and spray nozzles for special applications. It deals with the application of spray nozzles for all industrial purposes, also engineering data involved in same. A copy may be had free upon request.

The B. F. Sturtevant Co., Boston, Mass., has just published a 60-page catalog, No. 256, completely describing the "Sturtevant Type 6 Steam Turbine." The catalog is divided into three parts. Part I describes the construction and general principles of this type of turbine. Part II gives instructions relating to the care and operation of the machine, and Part III shows photographs and line drawings of itemized parts to be used for reference when ordering parts.

The Joseph Dixon Crucible Co., Jersey City, N. J., has issued a new booklet, "Graphite for the Boiler," which tells in a clear and concise way how to make boiler cleaning easy. An interesting table is included in this bookelt, which shows the extra cost of coal due to the various thicknesses of scale present in boilers. The manufacturers will be glad to send a copy of this booklet, No. 94-T, to anyone who is interested.

The Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has issued a 112-page illustrated catalog No. 107, entitled "Concentration." It shows the latest types and designs of machinery that have been developed to meet the demands of modern practice. Much data covering individual machines is included which should be of value and assistance in the selection of suitable and properly balanced units for concentration work.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7.95
Stove	7 95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F. o. b. mines, net tons	$2.60@3.10	$3.00@3.60
F. o. b. Philadelphia, gross tons	4.79@5.35	5.20@5.80
F. o. b. New York, gross tons	5.10@5.70	5.50@6.20
Alongside Boston (water coal), gross tons	6.85@7.35	7.10@7.85

Georges Creek is quoted at $3.70 per net ton, f. o. b. mines.

Pocahontas and New River are being quoted at $6.25@6.60 per gross ton f.o.b. Norfolk and Newport News, Va., in response to export demand. There are practically no sales for coastwise shipment.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Tidewater		Mine	Tidewater
Broken	$5.95	$7.80	Pea	$5.20	$6.95
Egg	6.25	8.10	Buckwheat	3.40	5.15
Stove	6.50	8.35	Rice	2.75	4.50
Chestnut	6.60	8.45	Barley	2.25	4.00

Bituminous

Current quotations on spot coal, net tons, at the mines average about as follows:

	Spot
South Fork (best)	$3.25@3.50
Cambria (best)	3.00@3.25
Cambria (ordinary)	2.65@2.90
Clearfield (best)	3.00@3.25
Clearfield (ordinary)	2.70@3.00
Reynoldsville	2.70@2.90
Quemahoning	3.10@3.25
Somerset (best)	3.00@3.25
Somerset (poor)	2.65@2.75
Western Maryland	2.50@2.75
Fairmont	2.10@2.35
Latrobe	2.60@2.65
Greensburg	2.50@2.60
Westmoreland ¾ in.	2.75@2.90
Westmoreland run-of-mine	2.50@2.60

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Anthracite Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	6.25	8.10	Rice	2.75	3.65
Stove	6.50	8.35	Boiler	2.50	3.50
Nut	6.60	8.45	Barley	2.25	3.15
Pea	5.20	6.80			

Illinois

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.40@1.60	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	....

Domestic quotations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	5.00@$5.50
Corona	3.50
Jagger	3.50
Montvallo	5.50@$6.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.85*@3.05	$2.55 $2.25@2.50
Mine run	2.10*@2.35	2.35 1.60@1.70
Screenings	1.50*@2.20	2.05 .90@1.00

* Indicates prices on independent coal.

Williamson-Franklin rate to St. Louis is $1.07½; other rates $0.92½.

New Construction

R. I., Providence—The Rhode Island Hospital, Eddy St., has had plans prepared for the construction of a 5 story, 78 x 143 ft. hospital. A steam heating system will be installed in same. Total estimated cost, $150,000. Kendall Taylor & Co., 93 Federal St., Boston, Mass., Arch.

R. I., Woonsocket—The Gold Mark Knitting Co. will soon award the contract for the construction of a 1 and 2 story, 90 x 135 ft. mill on Railroad St. Two 75 H. P. boilers, generators and motors will be installed in same. Total estimated cost $50,000. McClinton & Craig, 33 Lyman St., Engr.

Conn., Bridgeport—F. A. Cooper, Arch., 1024 Main St., soon receives bids for the construction of a 2 story, 65 x 214 ft. store and loft building, on Stratford Ave. and Kossuth St., for Mendelson Bros., 622 Water St. Electric power equipment and steam heating system will be installed in same. Total estimated cost, $60,000.

N. Y., New York (Bronx)—The Bronx Consumers' Ice Co., DeVoe Ave. and 180th St., is having plans prepared for altering its 2 story, 146 x 155 ft. ice plant. Total estimated cost, $60,000. Max Hansle, 3307 3rd Ave., Engr. and Arch.

N. Y., Brooklyn—The Board of Education, 500 Park Ave., New York City, is having plans prepared for the construction of a 4 story school on Howard Ave. and Prospect Pl. A steam heating system will be installed in same. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr. and Arch.

N. Y., Brooklyn—The Congregation Tiefereth Israel, c/o Shampan & Shampan, Arch., 50 Court St., is having plans prepared for the construction of a 2 story synagogue on 14th St. near 7th Ave. A steam heating system will be installed in same. Total estimated cost, $250,000.

N. Y., Brooklyn—A. A. Schwartz, 815 Flatbush Ave., will build a 1 story, 175 x 175 ft. theatre on Fulton St. and New York Ave. A steam heating system will be installed in same. Total estimated cost, $500,000. Work will be done by day labor.

N. Y., Brooklyn—Slee & Bryson, Engr. and Arch., 154 Montague St., will receive bids September 22, for the construction of a 3 story, 65 x 90 ft. office building, on Jay St. and Willoughby Ave., for the Home Title Insurance Co., Jay and Pearl St. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. Y., Jamaica—The Long Island Motion Pictures Co. will build a 135 x 140 ft. theatre on Fulton St. A steam heating system will be installed in same. Total estimated cost, $250,000. Work will be done by day labor.

N. Y., Jamaica—The St. Mary's Hospital, Shelton Ave., is having plans prepared for the construction of a 5 story, 100 x 150 ft. addition to hospital. A steam heating system will be installed in same. Total estimated cost, $250,000. F. J. Berlinbach, 260 Graham Ave., Brooklyn, Engr. and Arch.

N. Y., Kings Park—The State Hospital Commission, Capitol, Albany, will receive bids until September 10, for construction, heating, sanitary and electric work of building for Acute Patients, at Kings Park State Hospital, here.

N. Y., Long Island City—Board of Education, 500 Park Ave., New York City, is having plans prepared for the construction of a 4 story school on Curtis Ave., between Broadway and Belmont Ave. A steam heating system will be installed in same. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr. and Arch.

N. Y., New York—The Board of Education is having plans prepared for the construction of a 5 story addition to school at 205 East 109th St. A steam heating system will be installed in same. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., Engr. and Arch.

N. Y., New York—Buchman & Kahn, Engr. and Arch., 56 West 45th St., will receive bids September 15, for the construction of a 6 story, 75 x 200 ft. addition to factory, on Ave. D between 13th and 14th St., for the Eagle Pencil Co., 703 East 13th St. A steam heating system will be installed in same.

N. Y., New York—R. G. Cory, Arch. and Engr., 39 Cortland St., will receive bids about September 10, for the construction of a 6 story, 75 x 150 ft. factory, for the

C. Cory Co., 290 Hudson St. A steam heating system will be installed in same. Total estimated cost, $200,000.

N. Y., Rochester—The Polish Clothing Manufacturing Co., Inc., plans the construction of a 3 story, 75 x 75 ft. factory on Hudson Ave. and Avenue D. Steam heating plant, electric power and transmission will be installed in same. Total estimated cost between $60,000 and $75,000. Adam Norwich, Pres.

N. Y., Troy—Franklin W. Ward, Secy., State Board of Armory Commissioners, 158 State St., Albany, will receive bids until September 4 for building, heating, sanitary and electric work, for State Armory here.

Md., Annapolis—The Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to build a power house, and install 3 boilers here. Total estimated cost, $130,000.

Md., Baltimore—R. L. Harris, Arch., 2027 Kennedy Ave., is receiving bids for the construction of a 2 story, 60 x 90 ft. ice storage plant, for the Crystal Ice Co., Chester St. and North Ave. Total estimated cost, $70,000.

D. C., Washington—Spec. No. 3708—The Bureau of Yards and Docks, Navy Department, soon receives bids for installing mechanical equipment and piping for boiler shop, here. Estimated cost, $200,000.

Va., Hampton Roads—The Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to build an engine house, blacksmith, plumbing and machine shop, here. Total estimated cost, $160,000.

W. Va., Riverside—The Monongahela Valley Traction Co., Fairmont, plans to double the capacity of its power plant here, and extend high tension lines to Meriden, Gratton and Riverside, also install two 10,000-kw. turbines. Estimated cost, $1,000,000. G. M. Alexander, Fairmont, Ch. Engr.

N. C., Ronda—The Ronda Cotton Mills, Inc., is in the market for power plant equipment for the proposed 1 story, 80 x 300 ft. cotton mill which it plans to build. Total estimated cost, $250,000.

N. C., Wendell—The city will receive bids September 11, for a deep well and pump in connection with proposed waterworks and sewerage systems. Total estimated cost, $30,000. Gilbert White, Durham, Engr.

S. C., Charleston—The Bureau of Yards and Docks, Navy Department, Washington, D. C., will receive bids September 10, for the installation of mechanical stokers in central power plant here. Estimated cost, $11,000.

Ohio, Ansonia—G. L. McKibben, consult. engr., Vannert, will receive bids about September 10, for the installation of a water and light plant for the village.

Ohio, Cleveland—The Martin Barriss Co., 2048 West 3rd St., plans to construct a 2 story, 36 x 165 ft. saw mill and power house. A steam heating system will be installed in same. Total estimated cost, $100,000. Architect not selected.

Ohio, Cleveland—The Cleveland Plain Dealer Co., East 6th St. and Superior Ave., plans to build a 6 story, 40 x 198 ft. addition to publishing house. A steam heating system will be installed in same. Total estimated cost, $250,000.

Ohio, Cleveland—M. J. Hinkle, Huron Rd. and East 9th St., plans to build a 2 story, 125 x 140 ft. sales and service building on East 67th and Carnegie Ave. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ohio, Cleveland—H. P. McIntosh, Euclid Ave., plans to build a 3 story, 70 x 135 ft. addition to office, on Euclid Ave. A steam heating system will be installed in same. Total estimated cost, $150,000.

Mich., Detroit—Frank M. Pauli Co., 30 Shipherd Ave., plans to erect a 2 story, 30 x 80 ft. mill work factory, on Six Mile Rd. along the Grand Trunk Railroad. Electric motors to supply power will be installed in same. Total estimated cost, $13,000. Work will be done by day labor.

Mich., Detroit—Young Bros., 213 Franklin St., are receiving bids for the construction of a 1 and 2 story, 105 x 161 ft. factory, on Beufait Ave. Steam boiler and equipment, and electric motor for power, will be installed. C. W. Brandt, 1114 Kresge Bldg., Arch.

Mich., Lansing—The Hall Lumber Co., Michigan Ave. and Larch St., plans to construct a 2 story, 50 x 200 ft. millwork factory, on North Larch St. Electric motors for power will be installed in same.

Mich., Marysville—The Detroit Edison Co., David Whitney Bldg., Detroit, plans to construct an electric steam power plant to contain 30,000 kw. unit, along St. Clair River and Bunce Creek.

Mich., St. Louis—M. E. Hull, Secy., of the Board of Education will receive bids September 1, for the construction of a 2 story addition to the present Union school building, District No. 1. A steam heating plant, consisting of boiler, pump and fan, to be bid upon separately. Total estimated cost, $50,000. Cowles & Mutscheller, Chase Bldg., Saginaw, Arch.

Ill., Chicago—The Gramm-Bernstein Motor Truck Co., East Wayne and Scott St., Lima, Ohio, plans to construct a 2 story, 70 x 190 ft. sales and service building at 2439 Wabash Ave. A steam heating system will be installed in same. Total estimated cost, $150,000.

Ill., Chicago—Alexander L. Levy, Arch., 111 West Washington St., is receiving bids for a 3 story, 90 x 150 ft. theatre, at 2040 West Division St., for Reingold & Auerkach, 856 North Clark St. A steam heating system will be installed in same. Total estimated cost, $250,000.

Ill., Chicago—Marshall & Fox, Arch., 721 North Michigan Ave., are receiving bids for the construction of a 3 story, 100 x 150 ft. auto service station, on Indiana Ave. and 23rd St., for the Cadillac Automobile Co., 2301 South Michigan Ave. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ill., Chicago—Moores & Dunford, Eng., 38 South Dearborn St., are receiving bids for the construction of a 6 story, 50 x 120 ft. storage building, at 6345 Broadway, for Sidney & David. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ill., Chicago—The A. W. Shaw Co., 5 North Wabash Ave., is having plans prepared for the construction of a 2 story, 120 x 210 ft. office building, on Cass and Erie St. A steam heating system will be installed in same. D. H. Burnham & Co., 209 South LaSalle St., Arch.

Wis., Janesville—The Samson Tractor Plant is having plans prepared for a new heating plant here. The first unit of this plant will have a capacity of 2000 hp., and will be equipped with Sterling boilers and Taylor stokers. Frank D. Chase, 645 North Michigan Ave., Chicago, Ill., Engr.

Wis., Kiel—The Kiel Furniture Co. plans to build a 2 story, 40 x 160 ft. furniture building, on Main St. A steam heating system, and 2 new 5½ x 16 ft. boilers will be installed in same. Total estimated cost, $25,000.

Minn., Mountain Lake—The village is in the market for a motor driven double stroke well pump. H. C. Hanson, Clk.

N. D., Fort Yates—The Department of the Interior, Office of Indian Affairs, Washington, D. C., is receiving bids for the installation of an electric lighting plant here.

Mo., St. Louis—H. J. Wise, Engr., Post-Dispatch Bldg., will soon receive bids for the construction of a 2 story, 90 x 252 ft. addition to laundry, at 1745 South 18th St., for A. J. Feuerbacher, c/o Superior Laundry Co. Boilers will be installed in same. Total estimated cost, $80,000.

Mo., Sugar Creek—The Board of Education will soon award contract for the construction of a 2 story, 63 x 86 ft. school and 1 story, 24 x 50 ft. boiler house. A steam heating plant will be installed in same. Total estimated cost, $65,000. A. B. Anderson, 818 New York Life Bldg., Kansas City, Arch.

Texas Fort Worth—H. H. Morrison, Engr., Fullerton Bldg., St. Louis, Mo., will soon receive bids for the construction of a 17 story, 108 x 200 ft. and 10 x 220 ft. hotel here, on 8th and Commerce St., for the Winfield Hotel Co. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

Okla., Hobart—The city plans an election soon to vote on $135,000 bonds for the construction of an electric light plant. J. J. Hunt, Mayor. V. V. Long & Co., Oklahoma, Engr.

Okla., Holdenville—Hughes County is receiving bids for the construction of a 3 story, 88 x 96 ft. court house and jail. A steam heating sytem will be installed in same. Total estimated cost, $125,000. Layton, Smith & Forsyth, 701 May Bldg., Oklahoma, Arch.

Okla., Oklahoma City—First Church of Christ, Scientist, is receiving bids for building a 2 story, 90 x 100 ft. church. A steam heating system will be installed in same. Total estimated cost, $100,000. C. L. Butler, Tulsa, Arch.

Utah, Monti—The city has retained F. G. McGonagle, Engr., Salt Lake City, to prepare plans for an electric light plant. Total estimated cost, $25,000. Noted Jan. 7.

Ariz., Phoenix—The Union Oil Co. of Arizona, 15th and Santa Fe St. will build a plant, to consist of a warehouse, office, pump house, garage, storage tanks, etc. Total estimated cost, $100,000. Union Oil Co. of California, Union Oil Bldg., Los Angeles, Engr. Work will be done by day labor.

Ariz., Roosevelt—The Salt River Valley Water Users' Association, Phoenix, plans to construct a 5000 kw. steam generating plant for furnishing power to about 60 pumps which will be used to lower underground water level. Pumps are now being installed. C. A. Vander Veer, secy.

Ariz., Tempe—The Water Users' Association of Phoenix plan to construct a 5000 kw. steam generating plant at the Crosscut Canal, near here, to supplement the hydro-electric plant at Roosevelt. Total estimated cost, about $500,000.

Wash., Puget Sound (Bremerton P. O.)—Spec. No. 3837—The Bureau Yards & Docks, Navy Dept., Washington, D. C., plans to construct a reciprocating air compressor here. Estimated cost, $62,000.

Ore., Astoria—The Astoria Apartment Co. will soon award the contract for the construction of a 3 story, 60 x 200 ft. apartment hotel here. A vapor steam heating plant will be installed in same. G. M. McBride, Yeon Bldg., Portland, Pres. F. M. White, Chamber of Commerce Bldg., Porland, Arch.

Cal., Arcadia—The city voted $150,000 bonds to construct a 1,000,000 gallon reservoir and a smaller reservoir, sink a well, lay about 15 miles of pipe line and install 2 booster pumps and 1 pump at well. H. S. Gierlich, City Engr.

Cal., Grass Valley—The Grass Valley Bullion Exploration Co. plans to construct a quartz mine and is in the market for electrical hoist and pumps. Total estimated cost, $300,000. G. E. Mainhart, Supt.

Cal., Huntington Beach—The property owners on the Huntington Beach, Meca, are organizing an irrigation district to construct small dams in Santa Anna River, install pumps to lift water 75 ft. and construct pipe lines to irrigate about 2500 acres. G. F. Fowler, A. G. Thornton and J. Vaura comprise committee in charge.

Cal., Los Angeles—The Board of Public Service Commissioners will drill one hundred 8 and 12 in. wells in the Owens River Valley, Inyo County, to augment supply to the Los Angeles acqueduct. Pumps and pipe lines will probably be installed.

Cal., Los Angeles—The Board of Public Service Commissioners has filed claims for locations for city power plants on South Fork of Kern River. Total estimated cost, $10,000,000. E. F. Scattergood, 645 South Olive St., Engr.

Cal., Mare Island—Spec. 3982—The Bureau of Yards & Docks, Navy Dpartment, Washington, D. C., will soon award the contract for electric lighting and power systems, here. Estimated cost, $25,000.

Cal., Mare Island—Spec. 4018—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install a 4000 kw. turbo-generator, here. Estimated cost, $45,000.

Que., Montreal—The Allen Theatre Enterprises, Richmond St., E., Toronto, Ont., are having plans prepared, for a 2 story, 45 x 70 ft. theatre on McGill St., here. Steam boilers and equipment will be installed in same. Total estimated cost, $250,000. C. H. Crane and E. G. Kiehler, 2325 Dime Bank Bldg., Detroit, Mich., Arch.

Ont., Birch Cliff—Scarboro Township plans to install electrically driven centrifugal pumps in connection with proposed waterworks system. Total estimated cost, $100,000. E. James, 57 Adelaide St., East Toronto, Engr.

Ont., Chatham—The city plans to install a new waterworks system. Plans include intake, pumphouse and 5,000,000 gallon reservoir. Total estimated cost, $200,000. James, Landon & Hertzberg, Ltd., 36 Toronto St., Toronto, Engr.

Ont., Forest—The town council plans to contruct a new waterworks system. Electrically driven pumping equipment will be installed. James, Landon & Hertzberg, Excelsior Life Bldg., Toronto, Engr.

Ont., Hamilton—The Board of Education will recive bids until September 9 for the construction of a 2 story school on Hunter St., W. A steam heating system, electric motor and fan will be installed in same. Total estiamted cost, $125,000. F. W. Warren, Bank of Hamilton Bldg., Engr. and Arch.

Ont., Oshawa—The Gananoque Spring & Axle Co. will build a 1 story, 80 x 200 ft. factory and office building. A hot air system of heating will be installed. Total estimated cost, $100,000. Work will be done by day labor.

Ont., St. Catharines—The Public School Board will soon award the contract for the construction of two 2 story, 8 room, schools. Steam heating systems will be installed in same. Total estimated cost, $140,000. A. E. Nicholson, 46 Queen St., Arch.

CONTRACTS AWARDED

Mass., Attleboro—The Board of Education has awarded the contract for the construction of a 2 story, 57 x 106 ft. addition to Bliss school, to Everett O. Dexter, Attleboro. A steam heating system will be installed in same. Total estimated cost, $100,000.

Conn., Bridgeport—The Bryant Electric Co., 1421 State St., has awarded the contract for the construction of a 4 story, 60 x 220 ft. factory on Hancock Ave., to William Martin & Sons, 164 State St. Electric power and steam heating system will be installed in same. Total estimated cost, $90,000.

Conn., Hartford—The Connecticut General Life Insurance Co., 64 Pearl St., has awarded the contract for the construction of a 5 and 6 story office building, on Elm St., to Marc Eidlitz, 30 East 42nd St., New York City. A steam heating system will be installed in same.

Conn., Hartford—The Hartford Electric Light Co., 226 Pearl St., has awarded the contract for the construction of a power plant, on Colt's Meadows, to Stone & Webster, 147 Milk St., Boston, Mass. Total estimated cost, $1,000,000.

Conn., Hartford—The Hartford Fire Insurance Co., 125 Trumbull St., has awarded the contract for the construction of an office building on Farmington Ave., to Marc Eidlitz & Sons Co., 30 East 42nd St., New York City. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

Conn., Shelton—Sidney Blumenthal & Co., 37 Canal St., has awarded the contract for the construction of a 4 story, 50 x 120 ft. factory, and a 1 story, 40 x 180 ft shed, on Canal St., to the Thompson & Binger Co., 280 Madison Ave., New York City. Electric power and steam heating system will be installed in same. Total estimated cost, $70,000.

N. Y., Brooklyn—J. W. Masury & Son, 50 Jay St., has awarded the contract for the construction of a 6 story, 50 x 105 ft. factory building, on Plymouth and Jay St., to the Turner Construction Co., 244 Madison Ave., New York City. A steam heating system will be installed in same.

N. Y., Brooklyn—The Young Men's Christian Association, 1181 Bedford Ave., has awarded the contract for the construction of a 3 story, 75 x 100 ft. engineering school, on Bedford Ave. and Monroe St., to the Wills-Egeloff Co., 101 Park Ave., New York City. A steam heating system will be installed in same.

N. Y., Elmhurst—The Mispah Lodge, F. & A. M., has awarded the contract for the construction of a 2 story, 50 x 100 ft. temple, on Whitney Ave., to J. C. Woodruff, 1 Bridge Plaza, Long Island City. A steam heating system will be installed in same. Total estimated cost, $130,000.

N. Y., Long Island City—The Long Island City Savings Bank has awarded the contract for the construction of a 4 story, 70 x 80 x 100 ft. bank on Hunter Ave. and Academy Pl., to the Gillie-Campbell Co., 101 Park Ave., New York City. A steam heating system will be installed in same.

N. Y., Long Island City—The Wappler Electric Co., Harris Ave., has awarded the contract for the construction of a 2 story, 175 x 255 ft. factory, on Van Alst and Harris Ave., to the Turner Construction Co., 244 Madison Ave., New York City. A steam heating system will be installed in same.

N. Y., New York—The American Radiator Co., 104 West 42nd St., has awarded the contract for the construction of a 2 story, 115 x 185 ft. factory and warehouse, on Exterior and 149th St., to Post & McCord, 101 Park Ave. A steam heating system will be installed in same. Total estimated cost, $120,000.

N. Y., New York—The National Biscuit Co., 409 West 15th St., has awarded the contract for the construction of a 2 story, 124 x 161 ft. bakery, at 469-485 Bethune St., to Isaac Beers, 162 East 23rd St. A steam heating system will be installed in same. Total estimated cost, $125,000.

N. Y., New York—The New York Edison Co., Irving Pl. and 15th St., has awarded the contract for the construction of a 3 story, 55 x 75 ft. office and power house, at 31 Hester St., to the George Sykes Co., 70 East 45th St. A steam heating system will be installed in same.

N. Y., New York—The 110 West 55th St. Incorporation, 19 West 44th St., has awarded the contract for the construction of a 15 story hotel, at 110-120 West 55th St., to Fred T. Ley, 19 West 44th St. A steam heating system will be installed in same. Total estimated cost, $560,000.

N. Y., Syracuse—The Board of Contracts and Supplies has awarded the contract for installing heating and ventilating systems in the Frazer School, 741 Park Ave., to W. B. Goldie, 274 James St. Estimated cost, $14,876.

N. J., Newark—The Coacoanut Oil Co. has awarded the contract for the construction of a group of 2 and 3 story factories, to J. Lowery, Jr., 108 West 40th St., New York City. Steam heating systems will be installed in same. Total estimated cost, $150,000.

Pa., Philadelphia—The Hood Manufacturing Co., 19th and Westmoreland Aves., has awarded the contract for the construction of a 3 story, 80 x 140 ft. factory, to W. Steele & Sons, 16th and Arch St. A steam heating system will be installed in same. Total estimated cost, $120,000.

Penn., Philadelphia—The St. John's Home, 49th and Wyalusing Sts., has awarded the contract for the construction of 3 story school and dormitory buildings, to P. J. and J. T. Whelan, Lincoln Bldg. Steam heating systems will be installed in same.

Penn., Philadelphia—The A. Schoenhut Co., Adams and Seprivo St., has awarded the contract for the construction of a 2 story, 50 x 130 ft. factory and boiler house, on Amber and Venango St., to Philip Haibach, 1261 North 26th St.

Md., Baltimore—McCormick & Co., Pratt St. and Market Pl., has awarded the contract for the construction of an 8 story, 240 x 320 ft. warehouse on Light, Barre and Charles St., to M. A. Long & Co., Charles and Baltimore St. A 200 hp. boiler, 2 passenger and 4 freight elevators will be installed in same. Total estimated cost, $1,250,000.

N. C., Warsaw—The city has awarded the contract for deep well pumps, in connection with proposed waterworks system, to the Sydnor Pump & Well Co., 302 East Main St., Richmond, Va., $2290, boilers, to Schofield Sons Co., Hammond and Boundary St., Macon, Ga., $2900. Noted July 22.

Ohio, Cleveland—The National Lamp Works, Nela Park, has awarded the contract for the construction of a 2 story, 64 x 139 ft. service building, to Crowell, Lundoff, Little Co., Meriam Bldg. A steam heating system will be installed in same. Total estimated cost, $150,000. Noted August 19.

Ohio, Cleveland Heights—The Board of Education has awarded the contract for the construction of a 3 story, 125 x 200 ft. school, on Lee Rd., to the Phillip Kirschner Co., 1008 Hippodrome Bldg., Cleveland. A steam heating system will be installed in same. Total estimated cost, $300,000.

Ohio, East Canton—The Pennsylvania Lines West of Pittsburgh, Penobscot Bldg., Detroit, Mich., has awarded the contract for the construction of a 1 story, 90 x 3[illegible] ft. oil tank shop, at railway terminal here. A steam heating plant, consisting of boiler and accessories, will be installed in same.

Ohio, Washington—The Sunlight Creamery Co., c/o Cudahy Package Co., 111 West Monroe St., Chicago, has awarded the contract for the construction of a 1½ story, 60 x 235 ft. creamery here, to the W. Adams Co., 209 South La Salle St., Chicago. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ill., Cairo—The Bureau of Yards and Docks, Navy Department, Washington, D. C., has awarded the contract for new motor driven triplex pump, etc., to be installed in Post Office here, to J. J. O'Shea, 1203 Washington Ave. Estimated cost, $3250.

Ill., Chicago—The Cook County Paper Stock Co., 2325 LaSalle St., has awarded the contract for the construction of a 1 story, 600 x 1100 ft. warehouse, 1 story, 300 x 950 ft. factory, 3 story, 100 x 120 ft., and 1 story, 100 x 300 ft. heavy storage warehouse, and 1 story, 60 x 200 ft. garage and repair shop, on 31st St. and Kedzie Ave., to the Shank Co., 30 North LaSalle St. Steam power and heating systems will be installed in same. Total estimated cost, $1,000,000.

Ill., Peoria—The National Warehouse Co. has awarded the contract for the construction of a 7 story, 80 x 140 ft. warehouse, on Cedar and Washington St., to F. B. Hasbrouck, 325 Ellis St. A steam heating system will be installed in same. Total estimated cost, $200,000.

Wis., Port Washington—The city has awarded the contract for the construction of a 1 story, 40 x 180 ft. power plant on Main St., to Joseph Ubbink, Main St. Total estimated cost, $50,000.

Wis., Two Rivers—The Hamilton Manufacturing Co. has awarded the contract for the construction of a 2 story, 40 x 150 ft. power house on Main St., to W. W. Oeflein, 86 Michigan St., Milwaukee. Total estimated cost, $50,000.

Neb., Fall City—The city has awarded the contract for the construction of a 1 story power plant, to the Merkle Machinery Co., 508 Interstate Bldg., Kansas City, Mo. Total estimated cost, $43,100. Noted July 8.

Neb., Omaha—The Skinner Packing Co., 904 1st National Bank Bldg., has awarded the contract for the construction of an 8 story, 99 x 132 ft. cold storage plant, on 12th and Douglas St., to the G. W. Stiles Construction Co., 1218 1st National Bank Bldg. Total estimated cost, $500,000. Noted April 29.

Mo., St. Louis—The Ely & Walker Dry Goods Co., 16th St. and Washington Ave., has awarded the contract for the construction of an addition to its warehouse at 1519 Locust St., and 1510-18 St. Charles St., to James Stewart & Co., Inc., Boatmen's Bank Bldg. A steam heating system will be installed in same. Total estimated cost, $300,000.

Mo., St. Louis—The International Fur Exchange (Funsten Bros. Co.), 2nd and Market St., has awarded the contract for the construction of a 7 story storage house, on 4th and Market St., to J. A. Godfrey & Co., Wainwright Bldg. Elevators will be installed in same. Total estimated cost, $500,000.

Ariz., Phoenix—Dwight B. Heard, Central and Adams St., has awarded the contract for the construction of a 4 story, 70 x 148 ft. office building, to J. W. Martin, Phoenix. A steam heating system will be installed in same. Total estimated cost, $250,000.

Other Opportunities—

will be found on pages 143 to 153.

It is the "Opportunity" section of this paper. Examine it regularly. Whenever you have a business want—to locate or offer employment equipment or business opportunities, ***ALWAYS***

"Think SEARCHLIGHT First"

PRICES - MATERIALS - SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire 50-Ft. Lengths
Underwriters' 2½-in.	75c. per ft.
Common, 2½-in.	40%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.50	$0.33	$0.22

Steam—Discounts from List

First grade..... 30% Second grade..... 40% Third grade.... 45%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 65% Best grade..... 35%
Standard..... 50%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	45%	35%
St. Louis	40%	30%
Chicago	45%	40%
Birmingham	35%	30%
Denver	35–5%	30%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.50
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.10
Rubber sheet	.50
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... List

For low-pressure heating and return lines { 4-ply ..... 58% off; 3-ply ..... 60% off; 2-ply ..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5½	6.7	8½	14½
Fiber or sponge	8	10	6	13	9	18
Transmission	7	9	6	13	7½	17
Axle	4½	6	4	4.75	3–4	5½
Gear	4½	9	4½	7.5	5½	8
Car journal	22(gal.)	21 (gal.)	3½	4.7	6½	8

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	13.00	11.00 to 13.00	14.00	11.00 to 14.00
Colored mixed	9.00 to 12.00	8.50 to 12.00	11.00	9.50 to 12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$52.00	$58.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York		Cleveland	Chicago	
	Current	One Year Ago	Current	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$2.15	$1.86	$2.50	$2.48	$1.97
5-gal. cans	2.28	1.96	2.75	2.68	2.17

WHITE AND RED LEAD—Base price per pound:

	Red				White			
	Current		1 Year Ago		Current		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry and In Oil	In Oil	Dry and In Oil	In Oil
100-lb. keg	13.00	14.50	14.00	14.50	13.00	14.00		
25- and 50-lb. kegs	13.25	14.75	14.25	12.75	13.25	14.25		
12½-lb. keg	13.50	15.00	14.50	15.00	13.50	14.50		
1-lb. cans	16.00	17.50	.....	.....	16.00	17.00		
5-lb. cans	15.00	16.50	.....	.....	15.00	16.00		

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	50–10%	60%	55%
Tinned	50–10%	60%	55%

Boiler rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York....$4.72 Cleveland...$4.00 Chicago...$4.87 Pittsburgh...$4.20

Structual rivets, same sizes:

New York....$4.82 Cleveland...$4.10 Chicago...$4.97 Pittsburgh...$4.30

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$80–90	at Chester, Penn.
Chrome cement	net ton	45–50	at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	35–45	at Clearfield, Penn.
Clay brick, 2nd quality	net ton	30–35	at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50	at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90	at Chester, Penn.
Silica brick	net ton	41–45	at Mt. Union, Pa.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $ to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Silica, $48; fire clay, $42; magnesite, $85; chrome, $85.
Chicago—Second quality, $25 per ton.
Denver—Fire clay, $11 per ton.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	90.00	125.00	80.00	108.00	60.00	100.00
Commercial	50.00	70.00	18.50	23.00	13.00	24.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$21–26	$19.00
Cleveland	20.00	20.00
Chicago	16.50	19.00

In coils an advance of 50c. usually is charged.
Domestic iron (Swedish analysis) is selling at 15c. per lb.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft.	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft.	7.65	6.85	6.10	6.85
7 in. by 35 ft.	11.10	10.00	8.95	10.00
8 in. by 35 ft.	12.65	11.35	10.10	11.35
7 in. by 40 ft.	12.85	11.50	10.20	11.50
8 in. by 45 ft.	18.90	16.90	15.00	16.90
8 in. by 50 ft.	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft.	$9.00
12-in. butts, 6-in. tops, length 30-40 ft.	11.50
12-in. butts, 6-in. tops, length 41-50 ft.	12.50
14-in. butts, 6-in. tops, length 51-60 ft.	21.00
14-in. butts, 6-in. tops, length 61-71 ft.	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Steel			Iron		
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼ and ⅜	50½%	24%	⅛ to 1¼	39½%	23½%
½	54½%	40%			
¾ to 3	57½%	44%			

LAP WELD

2	50½%	38%	2	32½%	18½%
2½ to 6	53½%	41%	2½ to 6	34½%	21½%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	46½%	29%	½ to 1¼	39½%	24½%
½	51½%	39%			
¾ to 1¼	55½%	43%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	48%	37½%	2	33½%	20½%
2½ to 4	51%	40½%	2½ to 4	35½%	23½%
4½ to 6	50%	39½%	4½ to 6	34½%	22½%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
⅛ to 3 in. steel butt welded	47%	31%	43½%	34½%	57½%	44%
⅛ to 3 in. steel lap welded	42%	27%	45½%	30½%	53½%	41%

Malleable fittings, Class B and C, from New York stock sell at list + 12½%
Cast iron, standard sizes, 10–5% off.

BOILER TUBES — The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in	40½	3½ to 4½ in	15½
2½ to 3¼ in	30½	3 to 3¼ in	1
2¼ in	24	2⅛ to 2¼ in	+ 1
1¼ to 2 in	19½	2 to 2⅛ in	+16
		1¾ to 1⅞ in	+29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in	$327	1¾ in	$207
1¼ in	267	2 to 2½ in	177
1⅜ in	257	2¾ to 3¾ in	167
1½ in	207	4 in	187
		4½ to 5 in	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B.&S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	
Coils to 1,000 ft	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready

	Each, Net
Less than 12	$0.40
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft. and Over	Galvanized 1,000 Ft. and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
⅜	$71.15	$76.25	$17.04	$18.18	$5.38	$5.74
½	71.15	76.25	17.04	18.18	6.28	6.70
¾	93.96	100.86	22.43	23.93	8.97	9.57
1	138.39	149.09	33.19	35.41	11.66	12.44
1¼	187.91	201.71	42.62	45.31	16.10	17.12
1½	224.68	241.18	56.82	60.62	19.89	21.15
2	302.29	324.49	104.17	110.77	26.52	28.20
2½	477.95	513.05	170.46	181.26	37.88	40.28
3	625.00	670.91	454.56	483.36	56.82	60.42
3½	779.24	834.44	1,003.82	1,067.42	75.76	80.56
4	945.03	1,010.43	1,160.08	1,233.57	94.70	100.70

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
¼	250	$0.05½
⅜	250	.06
½	250	.09
⅝	200	.12
¾	200	.15
⅞	150	.18
1	100	.25
1¼	100	.33
1½	Odd lengths	.40
2	Odd lengths	.55

Coils..... 55% off
Less coils, 45% off

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L	$0.11	T. P. to D. P. S. B	$0.24
D. P. M. L	.18	T. P. to D. P. T. B	.38
T. P. M. L	.26	T. P. S. B	.33
D. P. S. B	.19	T. P. D. B	.54
D. P. D. B	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L	$0.33	$0.84	$1.68
T. P. M. L	.48	1.20	2.40
D. P. S. B	.42	1.05	.....
T. P. S. B	.81	1.80	.....
D. P. D. B	.78	2.10	.....
T. P. D. B	1.35	3.60	.....
T. P. to D. P. D. B	.90	2.52	.....

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$16.75
No. 16 cotton twisted	22.00
No. 18 cotton parallel	19.80
No. 16 cotton parallel	25.75
No. 18 cotton reinforced heavy	30.00
No. 16 cotton reinforced heavy	36.50
No. 18 cotton reinforced light	23.40
No. 16 cotton reinforced light	27.50
No. 18 cotton Canvasite cord	26.00
No. 16 cotton Canvasite cord	28.50

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp	100	$0.25
35-amp. to 60-amp	100	.35
65-amp. to 100-amp	50	.90
110-amp. to 200-amp	25	2.00
225-amp. to 400-amp	25	3.60
450-amp. to 600-amp	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp	100	.40
35-amp. to 60-amp	100	.9
65-amp. to 100-amp	50	1.20
110-amp. to 200-amp	25	2.00
225-amp. to 400-amp	25	5.00
450-amp. to 600-amp	10	8.50

Discount: Less 1-5th standard package..... 30%
1-5th to standard package..... 40%
Standard package..... 52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.75 C
0-30 ampere, less than standard package	6.00 C

LAMPS—Below are present quotations in less than standard package quantities.

Mazda B— Watts	Straight-Side Bulbs Plain	Frosted	No. in Package	Mazda C— Watts	Pear-Shape Bulbs Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.25	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current taps No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12.00	$14.00	$13.90	$25.00
12	13.25	15.70	18.05	30.70
10	18.30	21.00	23.85	41.50
8	25.54	28.60	32.70	56.77
6	.....	.....	51.40	.....
4	.....	.....	70.00	.....
2	.....	.....	101.80	.....
1	.....	.....	131.86	.....
0	.....	.....	160.00	.....
00	.....	.....	193.50	.....
000	.....	.....	235.20	.....
0000	.....	.....	288.60	.....

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver— Single Braid	Double Braid	Duplex	Birmingham— Single Braid	Double Braid	Duplex
14	$11.25	$14.00	$31.00	$11.24	$15.39	$27.17
10	21.85	28.25	56.75	21.58	34.73	48.55
8	31.05	38.30	77.95	30.11	58.59	66.49
6	48.80	52.65	.....	59.28	82.11	.....
4	70.00	75.30	.....	84.86	118.86	.....
2	104.85	112.45	.....	.....	155.40	.....
1	136.85	146.15	.....	.....	188.86	.....
0	.....	194.25	.....	.....	228.90	.....
00	.....	239.60	.....	.....	279.30	.....
000	.....	294.00	.....	.....	338.50	.....
0000	.....	358.25	.....	.....	446.75	.....

Pittsburg—23c. base; discount 50% St. Louis—30c. base.

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap. Key, Each	Keyless, Each	Pull, Each	Key, Each	⅜ In. Cap Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package..... +20%
1-5th to standard package..... +10%
Standard package..... −15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	36c. lb.
No. 18 B.&S. regular 1-lb. coils	37c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.120
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.3
200	4.40	6.76	10 14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%